AN ASSESSMENT OF CLIMATE CHANGE SCIENCE LITERACY AND CLIMATE CHANGE PEDAGOGICAL LITERACY OF GEOGRAPHY TEACHERS IN THE WESTERN CAPE

By

Raymond Ndubisi Anyanwu

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Supervisor: Prof. Peter Beets

Co-supervisor: Prof. Lesley Le Grange

Faculty of Education

Department of Curriculum Studies

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DECLARATION OF ORIGINALITY

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Raymond Ndubisi Anyanwu

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ABSTRACT

This survey research employed a criterion-referenced multiple-choice questionnaire to collect data from 194 FET Geography teachers in the Western Cape province to assess their level of literacy in both climate change science and climate change pedagogy, and to determine the influence of gender, age, qualification, specialisation, experience, grade mostly taught, their experience in providing instruction on climate change and the location of their school. Aspects of climate change science assessed include: climate processes and probable causes of climate change; climate change impacts; and climate change responses. Aspects of climate change pedagogy assessed include: the aims and significance of climate change education; and constructivist teaching principles and practice.

The collected data was analysed using percentage frequencies to determine the teachers' level of literacy in climate change science and climate change pedagogy; the Mann-Whitney and Kruskal-Wallis tests were used to determine the influence of the mediating variables on climate change science literacy and climate change pedagogical literacy, respectively. The results indicate that Geography teachers in the Western Cape Province demonstrated 'High' literacy in climate change science and 'Low' literacy in climate change pedagogy. Factors such as school location, gender, age and teaching experience were found to have a significant influence on climate change science literacy; whereas qualification, specialisation, grade mostly taught and experience in providing instruction on climate change did not. Conversely, teaching experience and grade mostly taught had a significant influence on climate change pedagogical literacy; whereas school location, gender, age, qualification, specialisation and experience in providing instruction on climate change did not. Based on these findings, it is recommended that professional development interventions in climate change pedagogy are required in order to expose Geography teachers to the aims and significance of climate change education and methods of facilitating problem-based, learner-centred instruction on climate change.

OPSOMMING

Hierdie opnamenavorsing het gebruik gemaak van ’n kriteriumverwysing- meerkeusige vraelys om data by 194 VOO Aardrykskunde onderwysers in die Wes-Kaap provinsie te versamel om hulle vlak van geletterdheid in beide die wetenskap en pedagogie van klimaatsverandering te bepaal en om die invloed van geslag, ouderdom, kwalifikasie, spesialisasie, ervaring, graad wat die meeste onderrig is, hulle ervaring van onderrig oor klimaatsverandering en die ligging van hulle skool te bepaal. Aspekte van klimaatsverandering wat geassesseer is, het klimaatsprosesse en moontlike oorsake van klimaatsverandering, impakte van klimaatsverandering en reaksies op klimaatsverandering ingesluit. Aspekte van die pedagogie van klimaatsverandering wat geassesseer is, het die doelwitte en betekenisvolheid van opvoeding oor klimaatsverandering en konstruktivistiese onderrigbeginsels en -praktyk ingesluit.

Die versamelde data is met persentasiefrekwensie geanaliseer om die onderwysers se vlak van geletterdheid in die wetenskap en pedagogie van klimaatsverandering te bepaal; die Mann-Whitney en Kruskal-Wallis toetse is gebruik om die invloed van bemiddelende veranderlikes op geletterdheid met betrekking tot die wetenskap en pedagogie van klimaatsverandering onderskeidelik te bepaal. Die resultate dui aan dat Aardrykskunde-onderwysers in die Wes-Kaap ‘Hoë’ geletterdheid in die wetenskap van klimaatsverandering en ‘Lae’ geletterdheid in die pedagogie van klimaatsverandering getoon het. Faktore soos ligging van die skool, geslag, ouderdom en onderrigervaring het ’n betekenisvolle invloed op geletterdheid in klimaatsverandering gehad, terwyl kwalifikasie, spesialisasie, graad wat die meeste onderrig is en ervaring van onderrig oor klimaatsverandering nie so ’n invloed gehad het nie. In teenstelling het onderrigervaring en graad wat die meeste onderrig is, ’n betekenisvolle invloed op geletterdheid in klimaatsverandering gehad, terwyl ligging van die skool, geslag, ouderdom, kwalifikasie, spesialisasie en ervaring van onderrig oor klimaatsverandering nie so ’n invloed gehad het nie. Op grond van hierdie resultate kan gesê word dat professionele ontwikkelingsingrypings in die pedagogie van klimaatsverandering nodig is om Aardrykskunde-onderwysers bloot te stel aan die doelwitte en belangrikheid van onderwys oor klimaatsverandering en metodes om probleemgebaseerde, leerdergesentreerde onderrig oor klimaatsverandering te fasiliteer.

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LIST OF ACRONYMS

CAPS	Continuous Assessment Policy Statement
CCE	Climate Change Education
CCP	Climate Change Pedagogy
CCPL	Climate Change Pedagogy Literacy
CCPLQ	Climate Change Pedagogy Literacy Questionnaire
CCS	Climate Change Science
CCSL	Climate Change Science Literacy
CCSLQ	Climate Change Science Literacy Questionnaire
CCSPCK	Climate Change Science Pedagogical Content Knowledge
CK	Content Knowledge
DBE	Department of Basic Education
FET	Further Education and Training
IPCC	Intergovernmental Panel on Climate Change
MDGs	Millennium Development Goals
NASA	National Aeronautics and Space Administration
NCCRP	National Climate Change Response Policy
NOAA	National Ocean and Atmospheric Administration
PBL	Problem Based Learning
PCK	Pedagogical Content Knowledge
PISA	Program for International Student Assessment
PK	Pedagogical Knowledge
SCAR	Scientific Committee on Antarctic Research
SEDA	Savannah Economic Development Authority
STEM	Science, Technology, Engineering, and Mathematics
UN	United Nations
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
WCDE	Western Cape Department of Education
WCESD	World Conference on Education for Sustainable Development

CHAPTER 1

INTRODUCTION

Global climate change is the worst environmental crisis ever witnessed in the Earth's history: it affects everyone everywhere on our planet. If we fail to take a sustained action now, continuous climate change may retard some of the progress already achieved by developing countries, including South Africa, towards the Millennium Development Goals (MDGs) of eradicating extreme poverty and hunger, achieving universal primary education, and promoting environmental sustainability. As a result, the South African National Climate Change Response Policy approves the teaching of climate change concepts and issues at all levels of schooling in South Africa to promote knowledge and understanding about climate change. This research project investigates how far Geography teachers in the Western Cape Province of South Africa are literate in climate change science and how far they are literate in climate change pedagogy. This introductory chapter, which lays the foundation for the study, presents the background to the study, the problem statement, the rationale for the study, the significance of the study, the purpose of the study, the research questions, the hypotheses, the research design, the organisation of the rest of the study and the summary of the chapter.

1.1 BACKGROUND TO THE STUDY

The most recent report (the Fifth Assessment Report) of the Intergovernmental Panel on Climate Change (IPCC, 2013) indicates that society is experiencing one of the worst environmental crises ever witnessed in the Earth's history, with increasing global mean surface air temperatures over the last one hundred years. In many regions, changing precipitation or melting snow and ice are transforming the hydrological systems and affecting the quality of water resources. Many terrestrial and marine species have modified their behaviour and activities in response to continuing climate change. These changes have a deepening impact on society, far more than any other environmental changes the Earth has ever witnessed. They affect everyone everywhere on our planet. However, the most at risk are populations in the developing countries, including South Africa, owing to limited financial and physical resources to initiate effective and efficient responses to the impacts of climate change. Continued global climate change could undermine some of the progress already attained by developing countries towards the Millennium Development Goals (MDGs) of eradicating extreme poverty and hunger, achieving universal primary education, and ensuring environmental sustainability (Pinter, 2013; National Research Council (NRC), 2011; Singh, Pandey, Gupta and Ravindranath, 2010; Ringler, Zhu, Cai, Koo and Wang, 2010; United Nations, 2000). It is the view of this study that, if the developing countries are to realise an inclusive sustainable development experience in the foreseeable future, policymakers must begin to consider schools as an agency to engender a climate change-literate population.

Historically, society often turns to education for solutions whenever it is confronted with complex ecological and social crises, notwithstanding education having its own challenges (Bank, 2012; Le Grange, 2011; Anderson, 2010; Rickinson, 2007). Society's reliance on education for solutions to environmental and social crises stems from the assumption that education can facilitate the development of the knowledge and skills that citizens require to mitigate environmental and social crises and empower them to make responsible choices in the event that the crises strike. The idea to develop a climate change-literate population through education, conceived during the United Nations (UN)-sponsored World Conference on Education for Sustainable Development (WCESD) in Bonn, Germany in April 2009, was an integral component of the international response to climate change. Since Bonn, several international gatherings with a focus on climate change education have been convened, including the UNESCO-sponsored international seminar held in Paris, France in July 2009 and the UNESCO Climate Change Initiative launched in 2009 (UNESCO, 2009a, 2009b).

Climate change education, as described by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2009a:2), is not merely about increasing people's environmental awareness. It is also about helping people to understand and address the impact of global warming today, while at the same time encouraging a change in the attitudes and behaviour required to act on climate change. Thus, the ultimate goal of climate change education is to promote the development of climate change literacy. Supporting the climate change education initiative is the assumption that education can help to promote climate change literacy and, by doing so, contribute to building a more resilient society. To translate policy into action, UNESCO has advised all countries to review and revise existing school curricula to integrate new climate change concepts and content, focusing on climatic processes and probable causes, effects and responses to climate change (UNESCO, 2009a, 2009b).

In compliance with UNESCO's statement on climate change education, South Africa developed a National Climate Change Response Policy, which recommends the teaching of climate change concepts at all levels of education in the country in an attempt to promote education and awareness about climate change (Republic of South Africa, 2010, 2009). Although there is an appreciation that education and awareness about climate change should straddle the whole range of school subjects, the discipline torchbearers of environmental and sustainable development education, as traditionally perceived, come from within disciplines such as Geography and Earth and Environmental Science. These disciplines deal with issues relating to climate change (Robinson, 2011:36-37). Among other subjects in the basic education system in South Africa, and due to the prescribed subject and skills in the current curriculum, Social Sciences and Geography provide a greater opportunity for understanding our complex world and the various forces influencing it.

In South Africa, Geography is taught as a sub-discipline of Social Sciences in the primary level, comprising Grades 4 to 9, and as a subject on its own at the high school level, comprising Grades 10 to 12. The Curriculum and Assessment Policy, commonly referred to as CAPS (Department of Basic Education, 2011:8) defines geography as the study of human and physical environments. Through geography, learners can better understand the complex world they live in and the environmental changes occurring in it. Geography, from the perspective of the Geography Education

Standards Project (1994:18), is an integrative discipline that integrates the physical and human dimensions of the world in the study of people, places and environments. The subject matter of Geography is the Earth's surface and the processes that occur and shape it, the relationships between people and environments, and the connections between people and places. These characteristics make the geographic perspective interdisciplinary, enabling scientists to examine complex issues, including those arising from the interaction of people and their environment. The geographic perspective employs the spatial and ecological approach in asking questions about how humans interact with their physical environments. It also serves as a lens that can be employed to analyse virtually any topic that has a spatial distribution, or simply anything that can be mapped (Brown and LeVasseur, 2006:2), including climate change.

Climate change is geographic in nature because it results from interactions between the Earth's natural complex systems and anthropogenic influences (IPCC, 2014; National Ocean and Atmospheric Administration [NOAA], 2011). Developing and understanding the systems and processes that result in climate change, and its impacts, and different ways of responding to it through Geography, will involve the organisation of geographical knowledge around the concept of place, spatial processes, spatial distribution and humans and the environment (Department of Basic Education, 2011:8-9), which are relevant in the development of climate change literacy. In the preface to his book, *Teaching secondary geography as if the planet matters*, Morgan (2012) stresses that the true worth of a school subject is revealed in the extent to which it accounts for, and responds to, the major issues of the time. Under the circumstance of the visible impacts of climate change on natural and human systems, the mere ability to encode and decode text information, which is the standard for distinguishing the literate from the illiterate, may not be adequate to understanding, and responding to, climate change; rather, it may require literacy in the contemporary sense, which refers to a flexible group of competencies needed to succeed in today's rapidly changing world (Holbrook and Rannikmae, 2009; Martinsson, 2009; Gamire and Pearson, 2006; Laugksch, 2000). This study therefore takes the perspective that accounting for, and responding to, climate change through education would involve repositioning school Geography as a medium through which schools can help to promote climate change literacy.

1.2 PROBLEM STATEMENT

Following the background to the study, it is assumed that, under the circumstance of global climate change, implementing climate change education in schools will help to promote the development of climate change literacy among learners. However, a number of researchers, such as Forest and Feder (2011), Robinson (2011), Dupigny-Giroux (2010), Pruneau, Khattabi and Demers (2010), Moser (2010), Leal Filho (2009) and Harrington (2008), contend that initiating climate change education in schools is one of the most problematic projects the field of education has ever witnessed.

The factors that make climate change education challenging are many and varied. They include the multidisciplinary nature of climate science, which makes explanation of the nature of the Earth's climate systems and the processes that occur in it complicated (SCAR, 2012; Forest and Feder, 2011; Pruneau et al., 2010; Blanchard and Vanderlinden, 2010); the diverse conceptions that people, including teachers and learners, hold about climate change are inconsistent with scientific accounts of climate change (Nwankwo and Onachukwu, 2012; Shepardson, Niyogi, Choi and Charusambat, 2011; Kilinc, Boyes and Stanisstreet, 2011); a scarcity of people with expertise in the science that supports climate change mitigation and adaptation (Heimlich and Ardoin, 2008; SEDA, 2008; Turner, 2008); and the emotions and anxiety associated with the direct impact of climate change on people and their livelihoods, particularly the most vulnerable in society, including children, women and the disabled (UNESCO, 2012; Tucci, Mitchell and Goddard, 2011; Doherty and Clayton, 2011). These factors relate to the science of climate change.

Besides the factors relating to the science of climate change, there are also other factors that make the implementation of climate change education in schools problematic that are not directly linked to the science of climate change, but rather with the approach in which it is conducted. These include the focus of climate change education on the transformation of people’s behaviour towards the environment, even when the people themselves do not see the need for environmental stewardship (Leiserowitz, Smith and Marlon, 2010; Læssøe, Schnack, Breitling and Rolls, 2009; Heimlich and Ardoin, 2008; Scearce, 2007; Fraser and Greehalgh, 2001); the lack of theoretical and conceptual frameworks for understanding and implementing climate change education, which also limits the development of new knowledge and understanding about how to promote climate change literacy (Dupigny-Giroux, 2010; Pruneau et al., 2010; Læssøe et al., 2009; Lorenzoni and Pidgeon, 2006); and the fact that many teachers in schools did not study climate change science and teaching methodologies during their teacher education programmes, which makes it difficult for them to apply the knowledge and skills to facilitate climate change instruction (Papadimitriou, 2004; Fortner; 2001). These factors are associated with the pedagogy of climate change.

With this exposition, the factors that make the implementation of climate change education challenging revolve around two main problems: literacy in climate change science and literacy in climate change pedagogy. Science is a human endeavour that deals with and seeks understanding of the natural world (National Research Council, 1996:24). The natural world, which science studies, consists of the physical or the material world, including the Earth and its climate. Thus, climate change science is a human endeavour to understand climatic process and probable causes of climate change, the impacts of climate change on human and natural systems, and the various ways humans and other species respond to climate change (UNESCO, 2009a; Hardy, 2005; Houghton, 2004; Bryant, 1997).

Pedagogy, on the other hand, is the practice of teaching framed and informed by a shared and structured body of knowledge comprising experience, evidence, an understanding of moral purpose and shared transparent values (Pollard, 2010:5). A typical pedagogical system consists of four components: policy, training and education, practice, and theory (Petrie 2013; Petrie, 2001)). Two different pedagogies have dominated the education landscape. Prior to the 1980s, traditional pedagogy, which is characterised by lecture and questioning, dominated the education system in many countries. However, in the past three decades, traditional pedagogy has witnessed intense criticism for offering the least opportunity for the development of problem-solving skills (Eiselein, 2003; Cascales, Solano and Leon, 2001), giving way to constructivist pedagogy, which is rooted in the belief that the knowledge the learner constructs by himself or herself is more enduring than the knowledge transmitted to him by someone else (Driscoll, 2005). UNESCO (2009a) describes this pedagogy as participatory, experiential, critical and open-ended. It is these attributes that define constructivist pedagogy as a learner-centred problem-solving approach to teaching.

Research indicates that the constructivist approach to teaching is more effective than the traditional approach in promoting higher order cognitive skills, including knowledge construction, inquiry, review of ideas and transfer of knowledge (Khalid and Azeem, 2012; Fessakis and Karakiza, 2011; Kenny and Wirth, 2009; Anyanwu, 2008; Malone, 2006; Baser, 2006; Zohar and Aharon-Kravetsky, 2005; Eryilmaz, 2004), including the ability to make logical and thoughtful environmental decisions (Le Grange et al., 2012; Arvai, Campbell, Baird and Rivers, 2010; Papadimitriou, 2004; Le Grange, 2002; Fraser and Greenhalgh, 2001). It is the advantage the constructivist approach of teaching has over the traditional approach that motivated many developed countries, including the United States, Canada, Australia and the United Kingdom, and some rapidly developing countries, such as China, India, Australia, New Zealand, Brazil and Mexico, to introduce curriculum reforms that promote constructivist teaching methodologies in schools (Null, 2004; Tatto, 1999; Lord, 1998; Brooks and Brooks, 1993).

Against this backdrop, this study takes the perspective that an understanding of climate change processes and probable causes, the impacts of climate change and the various ways of responding to it (climate change science), in addition to the aims and significance of climate change education and constructivist teaching principles (climate change pedagogy) is needed to promote climate change literacy in schools. Hence, the extent to which geography teachers in the Western Cape are literate in climate change science and climate change pedagogy needs to be investigated.

1.3 RATIONALE FOR THE STUDY

The idea to investigate the extent to which geography teachers in the Western Cape are literate in climate change science and climate change pedagogy was motivated by a number of circumstances, including my professional experience, my educational background, the identification with the university's research interest, and some conceptual and methodological gaps in climate change research.

Prior to conducting the study, from 2009 to 2012, the researcher lived in the Eastern Cape. During this period the researcher was a teacher of education studies at the Walter Sisulu University in Umtata. In the course of teaching in the pre-service and in-service programme, it became apparent that the students held diverse beliefs about climate change. Some students believed climate change to be real and that it already was affecting their communities. Others argued that climate change was orchestrated by the developed countries, such as the United States, Britain, France, Germany, Russia and Japan, to ensure that the poor countries in Africa and Asia did not catch up with the pace of economic growth in the present century. Besides these deep-rooted beliefs, it was also observed that many in-service teachers were not familiar with the constructivist approach in teaching. Both the in-service and pre-service group claimed that none of their lecturers had ever mentioned anything about constructivist teaching to them. It was at this time that the researcher started contemplating how he could take this message out of the lecture room to schools with the aim to promote knowledge and understanding about climate change and the constructivist approach to teaching.

The researcher's idea to integrate geographical and pedagogical knowledge and skills to develop an understanding of teachers' literacy in climate change and in climate change pedagogy was also motivated by the researcher's educational background. The researcher holds a degree in Geography and a degree in Educational Psychology, situating the researcher in environmental and education studies. It occurred to the researcher that an understanding of these two issues challenging the implementation of climate change education in schools may provide some insight that can be applied to design interventions on climate change science and climate change pedagogy. It was at this point that the researcher formulated the research topic, although not as refined as it appears on the cover page of this dissertation. It was in 2013 that the researcher proceeded to Stellenbosch University to commence the research project.

Through perusing some of the national policies on climate change, the researcher found that South Africa was among the most vulnerable countries in the world to climate change (Republic of South Africa, 2010, 2009). Stellenbosch University, where the study was conducted, is among South Africa's foremost tertiary institutions that seek ways of responding to the complex ecological and social issues confronting South Africa and the African continent in general, including climate change. In the foreword to the 2011 edition of a Stellenbosch University magazine, entitled ‘Research at Stellenbosch University: Showcasing Research Excellence’, the Rector and Vice-Chancellor of the University, Professor H.R. Botman (now late), highlighted five themes derived from the eight Millennium Development Goals that guide researchers at University. The five themes are: to eradicate poverty, promote human dignity and health, consolidate democracy and human rights, advance peace and security, and balance sustainable development with a competitive industry (Stellenbosch University, 2011:2). Guided by these themes, the University follows a science-for-society approach in helping to find solution to serious challenges confronting people in Stellenbosch, in South Africa, on the African continent, and in the world as a whole (Stellenbosch University, 2011). This assessment of climate change science literacy and climate change pedagogical literacy of Geography teachers in the Western Cape is situated within the themes that drive research at Stellenbosch University.

Through reviewing the work of other researchers in relation to knowledge of climate change and of the methods of teaching climate change content and concepts, the researcher found that research on Geography teachers’ literacy in climate change science and in climate change pedagogy was scanty. Some research conducted in South Africa, such as that by Makhobe (2009), Mokhele (2007) and Le Grange (2002), takes a generic view on the challenges of implementing environmental education in schools. Others, like Le Grange et al. (2012) and Dube (2012), take a sustainability perspective. Lowther, Ross, Burgete, Huang, Zoblostsky and Sivin-Kachala (2012), Nwankwo and Onachukwu (2012), Boon (2010) and Boylan (2008) conducted research on samples from countries like the United States, Nigeria, Australia and Turkey. Except for Lowther et al. (2012) and Nwankwo and Onachukwu (2012), none of the studies cited explored teachers' knowledge of the science of and teaching methodologies for climate change. Nwankwo and Onachukwu (2012) focused on generic classroom management principles. None of the researchers provides a conceptual framework and instrument to measure Geography teachers' literacy in both climate change science and climate change pedagogy in a single study. They also relied on measurement instruments developed by Western researchers, which validates Beets and Le Grange's (2005) claims that most assessments and their instruments are framed within a Western paradigm, which in most cases do not provide space for accommodating the ways that African learners, think. Hence Western assessment paradigms are culturally biased.

Among the studies cited, it was Vujovic (2013) that delved into FET geography teachers' knowledge and perception of climate change and evaluated the textbooks they used for climate change education using the qualitative approach with samples from Gauteng, South Africa. None of the studies focused involved samples of FET Geography teachers in the Western Cape, South Africa. It was this gap that motivated the researcher to think of designing a measurement instrument that takes into consideration the South African context.

1.4 SIGNIFICANCE OF THE STUDY

The outcomes of this study hopefully will make substantial and original contributions that build significantly on many different research interests in terms of theory, research, practice and policy on climate change education. Theory is a coherent explanation or a systematic account of relationships among phenomena (Garrison, 2000). Prior to this study there was no single theory of climate change scientific literacy and climate change pedagogical literacy. The conceptual frameworks developed by the researcher provide operational definitions of literacy in climate change science and in climate change pedagogy, and their elements/variables thereby offer a theoretical framework for the two concepts.

The outcomes of this study provide a multiple-choice questionnaire consisting of two main parts – one part focuses on climate change science and the other part focuses on climate change pedagogy. This instrument was designed taking the South African context into consideration. Prospective researchers may consider this instrument in their assessment of teacher literacy in climate change science and climate change pedagogy in other provinces in South Africa, and in other contexts with similar characteristics as South Africa.

The outcomes of this study help develop an understanding of the literacy status of Geography teachers in the Western Cape in relation to climate change science and climate change pedagogy. This understanding could be useful to policymakers in reviewing and revising existing policies on climate change and Geography education. Insights gained from this study may enable curriculum developers to design and implement professional development intervention programmes for teachers and teacher educators, to enhance their literacy in the science and pedagogy of climate change with the aim to improve the quality of climate change education in schools.

Notwithstanding this study's claim that constructivist teaching principles are suitable for educating learners about climate change, geography teachers have the freedom to select and apply the principles of other pedagogies that could facilitate the teaching and learning of climate change concepts and issues in schools.

1.5 PURPOSE OF THE STUDY

The main intent of this survey was to measure the level of climate change science literacy and of climate change pedagogical literacy of geography teachers in the Western Cape, in addition to the influence of variations in gender, age, qualification, specialisation, experience, grade mostly taught, their experience in providing instruction on climate change and the location of their school on climate change science literacy and climate change pedagogical literacy of geography teachers. In this study, climate change science literacy and climate change pedagogical literacy are hypothetical formulations constructed by the researcher for the purpose of this study. The elements, domains and operational definitions of these constructs, and the methodologies for measuring them are explained in the conceptual framework in Chapter 2. The conceptual framework identifies three subdomains of climate change science: climatic processes and probable causes of climate change, climate change impacts and climate change responses, and two subdomains of climate change pedagogy: the aim and significance of climate change education and constructivist teaching principles.

As at the time of this study there were no comprehensive instruments for measuring teacher literacy in climate change science with reference to the three sub-variables of climate change science, and for measuring climate change pedagogical literacy at two sub-variables, either in a single research project or in different research projects. This lack of existing measuring instruments necessitated the investment of time and effort to develop reasonably valid criterion-referenced instrument that measures both domains. The conclusions of the study are based on data collected from a representative sample of geography teachers in the Western Cape and analysed statistically. The participants were FET band geography teachers in public schools in the Western Cape. The reliance of this study on conclusions based on an analysis of data collected from a representative sample necessitates a survey research.

In pursuance of the purpose of this survey research project which is to determine how far geography teachers in the Western Cape are literate in climate change science and climate change pedagogy, the objectives were to:

a) Develop a conceptual framework, through a review of the literature, to understand the meaning and nature of climate change science literacy and climate change pedagogical literacy;
b) Based on a), develop a conceptual model that identifies the subdomains of climate change science;

c) Based on a), develop a conceptual model that identifies the subdomains of climate change pedagogy;
d) Based on a), develop an instrument to measure climate change science literacy and employ it to collect data from a sample of geography teachers;
e) Based on a), develop an instrument for measuring climate change pedagogical literacy and employ it to collect data from a sample of geography teachers;
f) Describe the representativeness of the sample to the population;
g) Describe the response rate of the study;
h) Describe the level of climate change science literacy of the respondents;
i) Describe the level of climate change pedagogical literacy of the respondents;
j) Statistically determine the influence of gender, age, qualification, specialisation, experience, grade mostly taught, their experience in providing instruction on climate change and the location of their school on the climate change science literacy of the respondents;
k) Calculate the reliability of the instrument measuring climate change science literacy;
l) Calculate the reliability of the instrument measuring climate change pedagogical literacy; and
m) Calculate the correlation between observation of climate change science literacy and observation of climate change pedagogical literacy.

These objectives were attained at different stages of the research process. Objectives a) to e) were attained conceptually based on logic, while objectives f) to m) were attained through statistical analysis of the observations.

1.6 RESEARCH QUESTIONS

In an attempt to achieve the purposes highlighted in section 1.5, this survey research project is navigated through two main research questions with reference to the two-pronged intent. Each main research question was translated into a set of subsidiary research questions based on the three subdomains of climate change science and the two subdomains of climate change pedagogy.

The first main research question (Main Research Question 1) is: How literate are geography teachers in the Western Cape in climate change science?

The subsidiary research questions for Main Research Question 1 are:

1. How literate are geography teachers in the Western Cape in climatic processes and the probable causes of climate change?
2. How literate are geography teachers in the Western Cape in climate change impacts?
3. How literate are geography teachers in the Western Cape in climate change responses?

The second main research question (Main Research Question 2) is: How literate are geography teachers in the Western Cape in climate change pedagogy?

The subsidiary research questions for Main Research Question 2 are:

1. How literate are geography teachers in the Western Cape in the aim and significance of climate change education?
2. How literate are geography teachers in the Western Cape in constructivist teaching principles?

1.7 THE HYPOTHESES

In survey research, samples are selected to learn more about the population (Sibanda, 2009). In the demarcation of the scope of the study, it was pointed out that all the participants of the study were FET phase geography teachers. However, these teachers varied in relation to demographics, such as gender, age, qualifications, specialisation, experience, grade mostly taught, their experience in providing instruction on climate change and the location of their school. These variables occur in categories. The question that the study asks is: If the categories are sampled from populations with identical distributions, what is the chance that random sampling would result in differences in the mean ranks with reference to literacy in climate change science and literacy in climate change pedagogy? It is on the basis of the demographic characteristics of the sample that the following null hypotheses are formulated:

A. Hypotheses on climate change science literacy:

- Ho1: There are no significant differences in the distributions of the scores of school location on literacy in climate change science.
- Ho2: There are no significant differences in the distributions of the scores of gender on literacy in climate change science.
- Ho3: There are no significant differences in the distributions of the scores of age on literacy in climate change science.
- Ho4: There are no significant differences in the distributions of the scores of qualification on literacy in climate change science.
- Ho5: There are no significant differences in the distributions of the scores of specialisation on literacy in climate change science.
- Ho6: There are no significant differences in the distributions of the scores of teaching experience on literacy in climate change science.
- Ho7: There are no differences in the distributions of the scores of grades mostly taught on literacy in climate change science.
- Ho8: There are no significant differences in the distributions of the scores of experience in providing instruction on climate change on literacy in climate change science.

These hypotheses were tested statistically and their results were used to determine which factors actually influence climate change science literacy of Geography teachers in the Western Cape.

B. Hypotheses on climate change pedagogical literacy:

- Ho1: There are no significant differences in the distributions of the scores of school location on literacy in climate change pedagogy.
- Ho2: There are no significant differences in the distributions of the scores of gender on literacy in climate change pedagogy.
- Ho3: There are no significant differences in the distributions of the scores of age on literacy in climate change pedagogy.

- Ho4: There are no significant differences in the distributions of the scores of qualification on literacy in climate change pedagogy.
- Ho5: There are no significant differences in the distributions of the scores of specialisation on literacy in climate change pedagogy.
- Ho6: There are no significant differences in the distributions of the scores of teaching experience on literacy in climate change pedagogy.
- Ho7: There are no significant differences in the distributions of the scores of grades mostly taught on literacy in climate change pedagogy.
- Ho8: There are no significant differences in the distributions of the scores of experience in providing instruction on climate change on literacy in climate change pedagogy.

These hypotheses were tested statistically and their results were used to determine which factors actually influence climate change pedagogical literacy of Geography teachers in the Western Cape.

The rationale for seeking to understand the influence of selected factors on Geography teachers' literacy in climate change science and literacy in climate change pedagogy is that they are together with scientists among the few categories of people who are expected to have the required knowledge and understanding of the science of climate change (National Center for Science Education, 2012; Union of Concerned Scientists, 2001). In addition, teachers are the most important school-based factor in influencing the education of learners (Aaronson, Barrow and Sander 2007; Rivkin, Hanushek and Kain 2005; Rockoff, 2004). The researcher believes that an insight into the variations in teacher characteristics will help to understand which teacher factors could have a greater influence on the development of climate change literacy in schools.

1.8 RESEARCH DESIGN

The research design is the overarching plan for the collection, measurement and analysis of data (Gray, 2009:131). It consists of several decisions, including the assumptions the researcher brings to the study; the procedure of inquiry (called strategies); and specific methods of data collection, analysis and interpretation (Creswell, 2009:3). In section 1.6, a set of clearly defined research questions to which objective answers were sought, are stated. ThiTs section discusses the measures put in place to ensure that all aspects of the study were carefully and precisely designed before data collection.

This study is a descriptive and explanatory survey. Kasunic (2005:3) defines a survey as a data-gathering and analysis approach in which respondents answer questions or respond to statements that were developed in advance. It begins with an extensive review of the literature in an effort to understand the context of the research problem and to gain some insight into different approaches and methods employed by other researchers in investigating related problems. All conclusions of this survey research are based on numerical or statistical descriptions and explanations of the characteristics of the respondents. It is the reliance of this survey on statistical evidence that situates it within the positivist paradigm, which involves analyses of data collected from a representative sample of the population of FET phase geography teachers in the Western Cape.

As a result of a lack of an existing assessment instrument that incorporates the three domains of climate change science and the two domains of climate change pedagogy, a conceptual framework was developed that shows the system of concepts, assumptions, expectations, beliefs and theories that support and inform the study (Robinson, 2011). Based on the conceptual framework, a criterion-references measurement instrument was developed for data collection. Provision was made to pilot the data collection instrument on a smaller sample prior to full-scale data collection to ensure that the instrument was fit enough to yield the data required to answer the research questions, eliminating or modifying weaker items so that only strong items were retained at the end of item analysis. Suggestions from experts on climate change and pedagogy in the Climate Change System Analysis Group of the University of Cape Town, and others from the Universities of Pretoria and Johannesburg were taken into consideration in the development of the assessment instrument.

The sample was 194 FET Geography teachers, selected with 'No Rule' sampling. The extent to which the sample is representative of the population was determined statistically. For research to be reliable it must demonstrate that, if it were to be carried out on a similar group of respondents in a similar context, similar results would be obtained (Oluwatayo, 2012:395). However, the issue of similar groups of respondents was not possible in this study because the design did not provide for replication. Of concern to this study, however, is the extent to which the items in the two main sections of the questionnaire (climate change science and climate change pedagogy) are consistent, which is a measure of instrument reliability. The internal consistency of the scores was calculated with Cronbach's alpha test and Guttman's split-half test. An alpha of 0.6 was targeted for each questionnaire. Also important to this study was how the scores of the two questionnaires correlated. Score correlation was calculated with the Spearman's test of correlation.

Data for answering the research questions was analysed with percentage frequency. The hypotheses were tested with the Mann-Whitney test and the Kruskal-Wallis test of differences between observation categories. The results are discussed in relation to the research questions, the hypotheses, the research context, the conceptual framework and the underlying assumptions. Insights emerging from the discussion were articulated in a grounded theory of geography teachers' literacy in climate change science and climate change pedagogy.

Despite the claim by the researcher that the research design for this study was fit to achieve its purpose, some choices made in the process of implementing the research design placed restrictions on the conclusions, such as the number of variables identified in the conceptual framework, the number of items included in the instruments, and the way in which the research participants were selected. Details of these are discussed in Section 5.2 in Chapter 5.

1.9 ORGANISATION OF THE REST OF THE STUDY

Chapter 2 presents an extensive review of pertinent literature on literacy, climate change, science and pedagogy in an effort to develop an understanding of the elements that constitute them and their relationships, including operational definitions of the constructs and their variables, the assumptions and the approaches/methods of measuring them. Chapter 3 presents the methodology and strategies/procedure of the study. It begins with the research setting and then progresses to the methodological choices and their rationale, and the research strategies and procedures, including techniques of data collection and analysis. Chapter 4 presents the findings, beginning with the demographic characteristics of the respondents, followed by the respondents' literacy in climate change science, the respondents' literacy in climate change pedagogy, the results of test of the hypotheses and the results of the test of instrumental reliability. Chapter 5 contains a discussion of the findings, limitations, conclusions, implications and recommendations of the study, including recommendations to improve practice and research. The chapter wraps up with a final statement by the researcher.

1.10 SUMMARY OF THE CHAPTER

Global climate change poses a serious threat to society for which a sustained global action is required including educating learners about climate change. This education requires teachers who are literate in the science and pedagogy of climate change. This survey research project investigates how far Geography teachers in the Western Cape are literate in climate change science and climate change pedagogy. The participants came into the study with variations in terms of location of school, gender, age, qualification, specialisation, teaching experience, grade mostly taught and experience in facilitating lessons on climate change. This research project also investigates the influence of the variations on teacher climate change science literacy and teacher climate change pedagogical literacy. A criterion-reference multiple-choice questionnaire that incorporates the elements/variables of climate change science and climate change pedagogy developed by the researcher was used for data collection from a sizeable sample of geography teachers in the Western Cape. The collected data was analysed with both descriptive and inferential statistics. The outcomes of the research project hopefully make original and significant contributions to the theory, research, policy and practice of climate change education. The next chapter presents the conceptual framework that guided the study.

CHAPTER 2

CONCEPTUALISING CLIMATE CHANGE SCIENCE LITERACY AND CLIMATE CHANGE PEDAGOGICAL LITERACY

> “I have never claimed to identify myself with what may be designated by this name. It has always seemed strange to me, it has always left me cold. Moreover, I have never stopped doubts about the very identity of what is referred to by such a nick-name” (Derrida, 1995).

This quotation is an expression of deep concern about subjectivity in the meaning of constructs, as it is not always possible to provide a universal definition of a construct. The quotation highlights the significance of an operational definition, particularly when a definition of a construct does not exist in the literature, or where it is defined in multiple ways. It is the former, not the latter, that motivated a definition of climate change science literacy and a definition of climate change pedagogical literacy.

In addition to the insight gained from Derrida (1995), the researcher also gained some insight from the experience of the biologist Bernard Heinrich and his colleagues (Heinrich and Heinrich, 1984) in their study of the behaviour of ant lions. Ant lions are a group of small insects that trap ants in pits that they have dug. After Bernard Heinrich and his colleagues completed their experiment, they found that their results differed from the results of previous observations of the behaviour of ant lions. In dismay, the team resolved to redo their experiment. It was then that they discovered that they had ignored the theories, concepts, variables, methods and procedures used by other researchers. The team then realised that the results of methodically collected data could be defective without theoretically sound assumptions.

For the purpose of coherence, this chapter begins with a conceptualisation of the notion of literacy, followed by a conceptualisation of climate change science literacy and climate change pedagogical literacy in an attempt to provide their operational definitions and the methodologies and methods of measuring them.

2.1 THEORISING LITERACY

The idea of exploring the various perspectives on literacy in this section is not to trace the historical evolution of literacy, but to get an idea of how different scholars have defined it and the elements that make up literacy so that the insights gained can be used to formulate the operational definition of climate change science literacy and climate change pedagogical literacy.

2.1.1 Traditional Perspective on Literacy

Traditionally, schools taught the "three R's: reading, 'riting and 'rithmetic". This denotes familiarity with literature or being well educated. It was only in the late 19th century that the concept of literacy has been used to refer to the skill for interpreting squiggles on a piece of paper as letters which, when put together, form words that convey meaning. Thus, the late 19th century marked the reconceptualisation of literacy as the ability to apply written language in a proficient manner. Despite these developments, the ability to read and write is still used to distinguish the 'civilised' from 'primitive', the 'noble' from the 'ignoble' or learned in most societies (Acevedo, 2009; Moats and Tolman, 2009; UNESCO, 2008; Thomas and Jolls, 2003).

For Feather and Sturges (1997), literacy exists in two layers with varying complexity. The first layer is 'surface literacy' and the second layer is 'core literacy'. Surface literacy refers to the ability to decode and encode messages in a written language, whereas core literacy refers to the process of the symbolic transformation of reality. Although the symbolic transformation of reality involves higher cognitive skills, the first step in the symbolic transformation of reality is coding and encoding. The manner in which people perceive reality is influenced, and influences, their way of life. In this sense, literacy is ideologically rooted. Ideologically rooted implies that literacy is contextualised with reference to the values that characterise the context in which it is defined (Asunda, 2012).

Besides having ideological value, literacy also has a pragmatic value. Pragmatism is about utility of knowledge and skills. It is about using one's knowledge and skills to solve problems in society. A literate person employs his or her skills for practical purposes that are functional literacy. A functionally literate person is one who can engage in all those activities in which literacy is required for the effective functioning of the community and also for enabling the individual to continue to use reading, writing and calculation for his own and the community's development (UNESCO, 2005:30). This view is consistent with The European Commission's (2009:21) concept of literacy, from the traditional perspective, as a practical command of the alphabet, the signs and symbols of reading and writing, and how to perform simple numeracy tasks. Thus, literacy is instrumental in the holistic development of an individual. Being literate means having the capacity to function effectively at individual and societal levels.

It can be drawn from the exposition of traditional literacy presented in this section that literacy is a skill acquired by people to solve problems associated mainly with the encoding and decoding of information. This feature makes literacy functional. Individuals who are illiterate cannot perform certain skills that literate ones perform. It is this functional character of literacy that demarcates the 'literate' from the 'illiterate'.

The next section discusses contemporary perspectives on literacy. Insights emerging from the exposition will help to highlight the differences between traditional views of literacy and the contemporary view of literacy. It will also make it possible to describe the general characteristics of literacy, which will be used to formulate an operational meaning of literacy in the context of this study.

2.1.2 Contemporary Perspective on Literacy

In the contemporary understanding, literacy refers to knowledge and a set of skills that grant literate individuals the ability to understand and relate to their surroundings (The European Commission, 2009:21). Baleiro (2011:16) describes literacy as a flexible group of skills that allow different professionals to define a group of specific competencies that are required to perform certain operations in that field of endeavour or domain of knowledge. As a result, different types of literacy exist in the literature, such as environmental literacy, scientific literacy, technological literacy, geographic literacy, media literacy, information literacy, chemical literacy, spatial literacy, climate literacy, sustainability literacy and mathematical literacy.

2.1.3 Varieties of Literacy

Although the contemporary perspective on literacy offers many kinds of literacy, only a few of them – scientific literacy, technological literacy, geographic literacy, environmental literacy, spatial literacy and media literacy are explored in this section. The purpose of exploring these literacies is to identify the features that they have in common and use them to formulate the operational definitions of climate change science literacy and climate change pedagogical literacy. However, an attempt was made to understand the methods used by other researchers to assess geographic literacy so as to gain some insight that will help in making choices about he methods of assessing climate change literacy and climate change pedagogy literacy of geography teachers in the Western Cape Province, which is presented in Chapter 3.

2.1.3.1 Scientific Literacy

Scientific literacy, defined by Holbrook and Rannikmae (2009:281), is the ability to be functional as a citizen in society (at home, at work, in the community), not purely on a knowledge level, but in making decisions and acting as a responsible person. Holbrook and Rannikmae (2009:276) outline the elements of scientific literacy as knowledge of the substantive content of science and the ability to distinguish from non-science; understanding science and its applications; knowledge of what counts as science; independence in learning science; ability to think scientifically; ability to use scientific knowledge in problem solving; knowledge needed for intelligent participation in science-based issues; understanding the nature of science, including its relationship with culture; appreciation of and comfort with science, including its wonder and curiosity; knowledge of the risks and benefits of science; and the ability to think critically about science and to deal with scientific expertise.

The Program for International Student Assessment ([PISA], 2006) developed a model for assessing scientific literacy from three key dimensions: scientific knowledge, scientific process, and situations and contexts, employing mainly attitude questionnaires and testing of cognitive abilities and knowledge (PISA, 2006). Scientific knowledge or concepts are the links that aid the understanding of related phenomena that can be applied and not just recalled. Scientific process is the ability to acquire, interpret and act upon evidence in relation to describing, explaining and predicting scientific phenomena; understanding scientific investigation; and interpreting scientific evidence and conclusions. Situations and contexts involve the application of scientific knowledge and the use of scientific processes, with a particular focus on science in life and health; science in earth and environment; and science in technology. PISA's assessments of scientific literacy focus on three basic areas, namely identifying scientific issues, explaining phenomena scientifically, and using scientific evidence (PISA, 2006:29). The scientific competencies for the three areas are as follows: identifying scientific issues, explaining phenomena scientifically, and using scientific evidence. These three aspects of scientific literacy involve knowledge, understanding and skills.

Drawing from Holbrook and Rannikmae (2009) and PISA (2006), scientific literacy is generic in nature. It is the competencies needed to function as an effective member of society. Individuals who are scientifically literate are conversant with scientific vocabulary, and understand the processes that occur in a system and the relationship between the different elements or parts of that system. They also understand the significance of science in society and can apply knowledge and skills in problem solving. These ideas were used in formulating the operational definition of climate change science literacy and climate change pedagogical literacy in sections 2.3.3 and 2.4.6 of this chapter.

2.1.3.2 Technological Literacy

Technology refers to the modification of the natural world to meet human wants and needs (ITEA, 2000/2002/2007:7). Technological literacy involves technological knowledge and technological capacity (Gamire and Pearson, 2006:37-38). It is not possible for an individual to be technologically literate without some knowledge and understanding of basic features of technology. Different descriptions of technologically literate persons have been provided in the literature. A technologically literate person, defined by the ITEA (2000/2002/2007:9) understands, in increasingly sophisticated ways that evolve over time, what technology is, how it is created, and how it shapes society, and in turn is shaped by society. Thus, individuals who are technologically literate have the ability to use concepts from science, mathematics, social studies, language, arts and other content areas as tools for understanding and managing technological systems. They demonstrate the ability to use a strong system-oriented, creative and productive approach to thinking about and solving technological problems (ITEA, 2003:11-12).

Collier-Reed (2008:24) describes technologically literate persons as those who understand the nature of technology, have a hands-on capability and capacity to interact with technological artefacts, and are able to think critically about issues related to technology. In the International Technology Education Association usage, technological literacy is the ability to use, manage, assess and understand technology. The ability to use technology involves the successful operation of the system of the time. This includes knowing the components of existing technologies and human adaptive systems and knowing how the systems behave. The ability to manage technology involves ensuring that all technological activities are efficient and appropriate. Assessing technology involves being able to make judgements and decisions about technology on an informed basis, rather than on emotion. Understanding technology involves the ability to understand and synthesise facts and information into new insights (ITEA, 2003:9).

Gamire and Pearson (2006:38) identify three key components of technological literacy. These include knowledge, critical thinking and decision making, and capabilities. This view is consistent with the NAE and NRC's (2002) framework for assessing scientific literacy, which identified three key elements of technological literacy and the characteristics of a technologically literate person: knowledge of fundamental concepts and principles of technology, critical thinking and decision making on issues relating to technology, and capabilities or the ability to solve problems relating to technology.

2.1.3.3 Geographic Literacy

Geographic literacy evolved out of the urgency to restore geographical education. In an article entitled 'The nature of geographic literacy', Backler and Stoltman (1986) explain that people have flawed notions about geography literacy - that a geographically literate person is one who could name where things or places are located in the world. Bliss (2005) explains that knowing about where things are located is a first step in the development of geographic literacy. The second level of literacy pertains to the physical and human characteristics of diverse places throughout the world. Understanding the characteristics of places in the world goes beyond the memorisation of factual information. It involves making comparisons between phenomena, both spatially and temporally, which necessitates higher-order cognitive skills as opposed to mere memorisation of factual information, which requires lower-level cognitive skills. According to the Geography Education Standards Project (1994:34), a geographically literate person is geographically informed – that is, a person who sees meaning in the arrangement of things in space; sees relations between people, places and the environment; uses geographic skills; and applies spatial (space and place) and ecological (human/environment interaction perspectives) to a life situation. Looking closely at these competencies, one could infer that being geographically informed means having the knowledge and skills required to analyse spatial and ecological relations.

Different approaches and methods have been used by researchers to assess the geographic literacy of individuals. One such study is the National Geographic-Roper 2006 Global Geographic Literacy Survey, which assessed the geographic knowledge of 3 250 young adults in nine countries, including the United States. The sample was adults aged 18 to 24 years old from the following countries: the United States, Canada, Mexico, France, Germany, Italy, Sweden, Great Britain and Japan. The skills assessed included attitudes toward geography, knowledge of current events, international issues, map-reading skills and world geography, map skills, knowledge of geography related to global issues and current events, and demographic profile. Data was collected through interviews. A total of 300 interviews were conducted in each country. In the United States nearly 500 interviews were conducted with 18- to 24-year-olds and an additional sample of more than 300 25- to 34-year-olds. The results show that knowledge of geography among young adults in the United States trails that of young adults in most of the other countries that participated in the survey. Some respondents outside the United States also struggled with basic geography facts, most remarkably young adults in Mexico and, to a lesser degree, those in Canada and Great Britain (National Geographic Education Foundation, 2006).

Misheck, Ezra and Mandoga (2013) assessed geographic literacy and world knowledge among Open Distance Learning Students in Zimbabwe. The survey instrument for this study was adapted from the National Geographic – Roper 2002 and 2006 Global Geographic Literacy Survey (National Geographic Education Foundation, 2002, 2006). The sample was 103 students. General descriptive statistics, such as frequency and mean, were used to describe the data. The scores from the questions were calculated in Excel. Data was analysed statistically using the Mann-Whitney U and Kruskal-Wallis tests for differences in means of observation among groups. The results show that the respondents performed well in the assessment of geographic literacy and world knowledge, with an overall pass rate of 81%.

The account of geographic literacy discussed in this section indicates that geographic literacy is concerned with geographic perspectives and geographic skills that can be utilised to analyse geographic issues, including global environmental issues. Geographic literacy is often assessed with quantitative, descriptive and explanatory surveys, with randomly selected samples and, in most cases, data is collected with questionnaires and/or interviews and analysed with descriptive and inferential statistical techniques. The researcher’s motivation for exploring the methods of assessing geographic literacy is that climate change is geographic in nature and the methods used in this study are consistent with the ones used in the field and as described above.

2.1.3.4 Environmental Literacy

Environmental change and the resultant environmental degradation that characterised this century threatens society in many ways that have motivated advocacies, conferences and awareness campaigns at different levels on the need to promote environmental literacy. The latter is seen as the ability to recognise that one's choices have an impact on the environment; to identify the most sustainable solution to a problem; and to be able to act in the most environmentally friendly way on that solution (Abiolu and Okere, 2011:4). It is the capacity of an individual to act successfully in daily life on the broad understanding of how people and societies relate to each other and to natural systems, and how they might do so sustainably. This requires sufficient awareness, knowledge, skills and attitudes in order to incorporate appropriate environmental considerations into daily decisions about consumption, lifestyle, career and civics, and to engage in individual and collective action (Campaign for Environmental Literacy, 2011).

Environmental literacy assessment is relatively new, with the first wave of national assessments dating back to the 1970s. The majority of frameworks for environmental literacy assessments were based on the objectives of environmental education, namely awareness, knowledge, attitudes and participation in assessing environmental literacy (Hollweg, Taylor, Bybee, Marcinkowski, McBeth and Zoido, 2011; Marcinkowski, 2011; Makki, Abd-el-Khalick and Boujaoude, 2003; Simmons, 1995). Holloweg et al (2011:3) describes an environmentally literate person as one possess, to varying degrees, the following characteristics:

- "The knowledge and understanding of a range of environmental concepts, problems and issues;
- A set of cognitive and affective dispositions;
- A set of cognitive skills and abilities; and
- The appropriate behaviour strategies to apply such knowledge and understanding in order to make sound and effective decisions in a range of environmental contexts" (Hollweg et al., 2011:3).

The first item involves knowledge. The second involves attitudes. The third item involves skills. The fourth item involves understanding. These characteristics represent three levels of cognition: knowledge, understanding and skills. An individual must function at the three levels of cognition to be able to understand and find solutions to environmental problems in society. Thus, an environmentally literate individual is one who possesses knowledge about the environment and issues related to it, and is capable of and inclined to further self-directed environmental learning/or action (NAAEE, 2000).

2.1.3.5 Spatial Literacy

The term *spatial* relates to space. Spatial information is used in many different applications, ranging from the simple location of places to optimising the routing of the complex determination of spatial patterns of natural or man-made phenomena, including decisions for development purposes. However, spatial thinking is emphasised less in schools and society than the basics of reading, writing and numeracy, and in no way near the sciences and social sciences and other signature components of the average school curriculum. It is crucial to understand that spatial thinking is an important component of science, technology, engineering and mathematics, as well as other disciplines that have to do with spatial configurations and their properties. Thus, an understanding of spatial abstractions is important for informed citizens (Newcombe, 2006).

Spatial literacy is the ability to apply a broad range of perspectives, knowledge, skills, habits of mind or dispositions to define space, such as height, depth, proximity and distance, with a view to understand and describe the natural and social world, and is referred to as spatial thinking (Bednarz and Kemp, 2011:20). It is the ability to capture and communicate knowledge in the form of maps, to understand and recognise the world as viewed from above, to recognise and interpret patterns, and to know that geography is more than just a list of places on the Earth’s surface. It also incorporates seeing the value of geography as a basis for organising and discovering information, and comprehending basic concepts relating to scales and spatial resolutions (Goodchild, 2006).

The National Research Council in the USA (2006) provides a framework that identifies the key components of spatial literacy as the concept of space, tools of representation and processes of reasoning. Thus, to think spatially one must develop knowledge of spatial concepts such as direction, distance and spatial association; attain skills in constructing and interpreting graphical representations, including diagrams, graphs and maps; and acquire and practise the cognitive strategies that facilitate problem solving and decision making in spatial contexts. Thus, spatial literacy is the outcome of spatial thinking and spatial reasoning.

2.1.3.6 Media Literacy

Media literacy refers to the ability to formulate a realistic response to complex problems affecting society by assessing, analysing, evaluating and communicating information in a variety of forms. It is an understanding of the media and the use of the media as a source of information, enrichment, empowerment and communication (National Association for Media Literacy Education, 2013; Wan, 2006). According to Livingstone (2004:2), media literacy is the ability to access, analyse, evaluate and create messages across a variety of contexts. Martinsson (2009:30) defines access as both physical access and the ability to use different forms of media, while analysis and evaluation entail the ability to seek, locate and select information to suit individual needs, and to evaluate the information according to parameters, including truthfulness, honesty and the interest of the broadcaster. A media-literate individual should be able not only to access, analyse and evaluate information, but also to produce material and create online content.

Livingstone and Thumin (2003:21) insist that media literacy cannot develop until access to media and information technologies is fairly and routinely embedded in the daily life of the public. For Martinsson (2009), media literacy facilitates the development of a number of skills, including critical thinking, problem solving, personal autonomy, and social and communicative skills. These are all skills relevant for building an informed and active citizenry. In relation to the assessment of media literacy, Livingstone and Thumin (2003) note that different research foci, methodologies and samples are employed, making it difficult to draw comparisons. In addition, the majority of studies are based on small samples and focus on particular aspects of media literacy, making it difficult to produce a general picture.

Based on the perspectives on literacy presented in this section, it is deduced that literacy is a set of competencies/skills needed to function effectively in society. Functioning effectively in society does not require just one skill; it requires a combination of skills. However, no individual could be literate in all facets of life. People can be literate in some things and not in others, depending on the type of work we do or the type of environment we live in.

Through the various perspectives on literacy explored in this section the researcher developed some insights that were used to formulate the operational definitions of literacy discussed in the next section.

2.1.4 Operationalising Literacy

2.1.4.1 Identifying the aspects of literacy

The information in Figure 1 indicates that there are three aspects of literacy: remembering, understanding, and skills. These three aspects of literacy do not exist in isolation with or independent of one another; rather, they are intersected. By intersecting means that it is not possible to draw a clear-cut line to demarcate where one aspect starts and the other ends. However, one of the criteria that can be used to distinguish them is cognition level – the level of thinking and other mental processes that are involved when performing a specific task, which suggests that there are levels of literacy based on cognition.

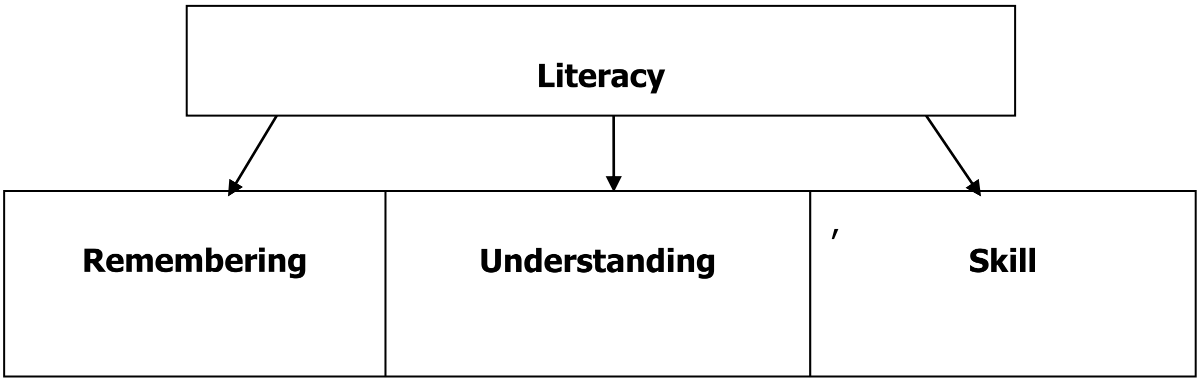

Figure 1: Aspects of Literacy

In psychological literature, the different activities people engage in require different levels of thinking or cognition. Ebel (1965) and De Jong and Ferguson-Hessler (1996) developed models for categorising the different levels of cognition. Their models were used mainly for science concepts, but Bloom's model, which was later revised by Krawthwohl (2002) cuts across subject lines. For Bloom (1956) cognitive processes is organised from the most simple – the recall of knowledge, to the most complex – making judgements about the value and worth of ideas. Based on this thinking, Bloom (1956) categorised cognition into six levels: knowledge (recall information), comprehension (understand the meaning, rephrase a concept), application (using information or concept in a new context), analysis (breaking information into smaller components to understand it better), synthesis (putting ideas together to derive a new concept) and evaluation (making judgement about value). The categorisation of cognition has been criticised for over fragmentation of thinking (Anderson, 2002, 2000; Marzano, 2000), resulting in the revision of Bloom's model by his former student Lorin Anderson in 1999 and by Krathwohl (2002).

Krathwohl (2002: 214-215) provided two main aspects/dimensions of knowledge: the knowledge dimension and the cognitive process dimension. The knowledge dimension of cognition encompasses four cognition levels, namely factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge. The cognitive dimension encompasses remembering (retrieving relevant knowledge from long-term memory), understanding (determining the meaning of instructional messages, including oral, written and graphic communication), applying (carrying out or using a procedure in a given situation), analysing (breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose), evaluating (making judgments based on criteria and standards), and creating (putting elements together to form a novel, coherent whole or make an original product). A closer look at Krathwohl's (2002) two dimensions of knowledge reveals that the knowledge dimension could be more suitable for assessment of the product of learning, whereas the cognitive process dimension could be more suitable for the assessment of processes of learning. Considering that the focus of this study is on what geography teachers already 'know' about the science and pedagogy of climate change implies that the knowledge dimension component of Krathwohl's model is more appropriate for the assessment of geography teachers' climate change science literacy (CCSL) and climate change pedagogical literacy (CCPL) than Bloom's (1956) model. This is because the purpose of the study is to assess how far teachers are literate in climate change science and climate change pedagogy, as they have already completed their education.

From the knowledge dimension perspective, factual knowledge refers to the essentials that individuals must know in order to be acquainted with a discipline or to solve problems in a particular subject. Individuals functioning at a factual level of knowledge are familiar with the terminology and definitions in a particular subject. At the factual level the individual recalls and reproduces information verbatim, often with little transformation or extended processing of the target knowledge. Tasks at this dimension of knowledge require the individual to list, identify, and define concepts, object, place or events (Krathwohl, 2002).

Conceptual knowledge refers to knowledge of the interrelationships between the basic elements within a larger structure that enable them to function together. Conceptual knowledge is useful for classifying or categorising objects, events and ideas; understanding the principles underlying some events or processes; and is capable of making generalisations, including an understanding of theories, models and structures underlying events, ideas and processes (Krathwohl, 2002).

Procedural knowledge is knowledge of how to do something, or methods of inquiry and criteria for using skills, algorithms, techniques and methods. It encompasses knowledge of subject-specific skills and algorithms, knowledge of subject-specific techniques and methods, and knowledge of criteria for determining when to use appropriate procedures (Krathwohl, 2002).

Metacognitive knowledge is awareness and knowledge of one's own cognition. It includes strategic knowledge, knowledge about cognitive tasks, including contexts and conditions about given tasks, and self-knowledge (Krathwohl, 2002). On the account that metacognition is the knowledge about and regulation of one's cognitive activities in learning processes (Scott and Berman, 2013; Veenman, Van Hout-Wolters and Afflerbach, 2006), it would be difficult to assess metacognition based on the previous learning of a subject. Therefore, this study focuses on the first three levels of Krathwohl's model: Remembering of facts, conceptual knowledge, and procedural knowledge. The description and area of emphasis of the first three levels of cognition provided by Kratwthwohl (2002) are summarised in Table 1.

Table 1: Levels of Cognition and their emphasis

Cognition level	Description	Area of emphasis
Remembering Factual)	Knowing the rudimentary of a subject or discipline	Identifying concepts - objects, places, events, and time Using appropriate terminology in the discipline
Understanding (Conceptual)	Understanding the underlying concepts and their relationships	Categorising objects, places, events, and time based on principles; make generalizations, formulate theories, build models, and make inferences
Procedural (Subject-specific skills)	Applying concepts and principles to solve problems in a specific disciple	Showing awareness of methods of solving a specific problem Determining where, when, and how specific methods and procedures can be used; Solve specific problems

2.1.4.2 Operational definition of literacy

With reference to Table 1, the lowest level of literacy is remembering or knowing the rudiments of a discipline. At this level, the individual is capable of identifying concepts, including objects, places, events and time, in addition to using appropriate terminology. The second level of literacy is understanding or conceptual literacy, which is intermediate in terms of cognition level. Conceptual literacy involves knowing the underlying concepts of a subject matter or the interrelationships among the concepts. Individuals functioning at this level are able to categorise objects, places, events and time, based on a set of principles. They are also able to make generalisations, formulate theories, build models, and make inferences. These activities require a higher level of cognition to carry out than in remembering of facts. The third and highest level of literacy is procedural literacy, which involves applying concepts and principles to solve problems in a specific discipline. Individuals who are literate at the procedural level demonstrate awareness of methods to solve specific problems. They are able to determine where, when and how specific methods and procedures can be used, and can solve specific problems. This model of literacy was used as a framework for the development of the items of the measuring instrument, discussed in Chapter 3.

Figure 2 shows the relationship between the three aspects of literacy and the three levels of cognition. Information in Figure 2 shows that factual aspect of literacy is concerned with rudimentary knowledge of a subject matter and is related to the factual cognition. The understanding aspect of literacy is related to conceptual cognition. The skill aspect of literacy is related to procedural cognition. Classification of literacy in terms of the type of action performed and in terms of levels of cognition involved presents two possible but different views on literacy, which have implications for the meaning and application of literacy in diverse contexts. On the one hand, literacy can be defined as ability to solve problem. Here the criterion to distinguish one person from another is the basis of performance when confronted with a problem. Problem solving involves all levels of knowledge - remembering, understanding and skill. In this instance, literacy can be defined as the remembering of facts, understanding and skill needed to solve a specific problem. Conversely, literacy can be defined in terms of depth of cognition as factual literacy, conceptual literacy and procedural literacy. For the purpose of this study, literacy as performance of action is used in formulating operational definitions of climate change science literacy and climate change pedagogical literacy, whereas literacy as cognition is applied during instrumentation process in which the items of the instrument are categorised according to level of cognition, as factual, conceptual and procedural. Details on how these three levels of literacy were applied during instrument development are provided in Chapter 3, Section 3.3.3.2.5.

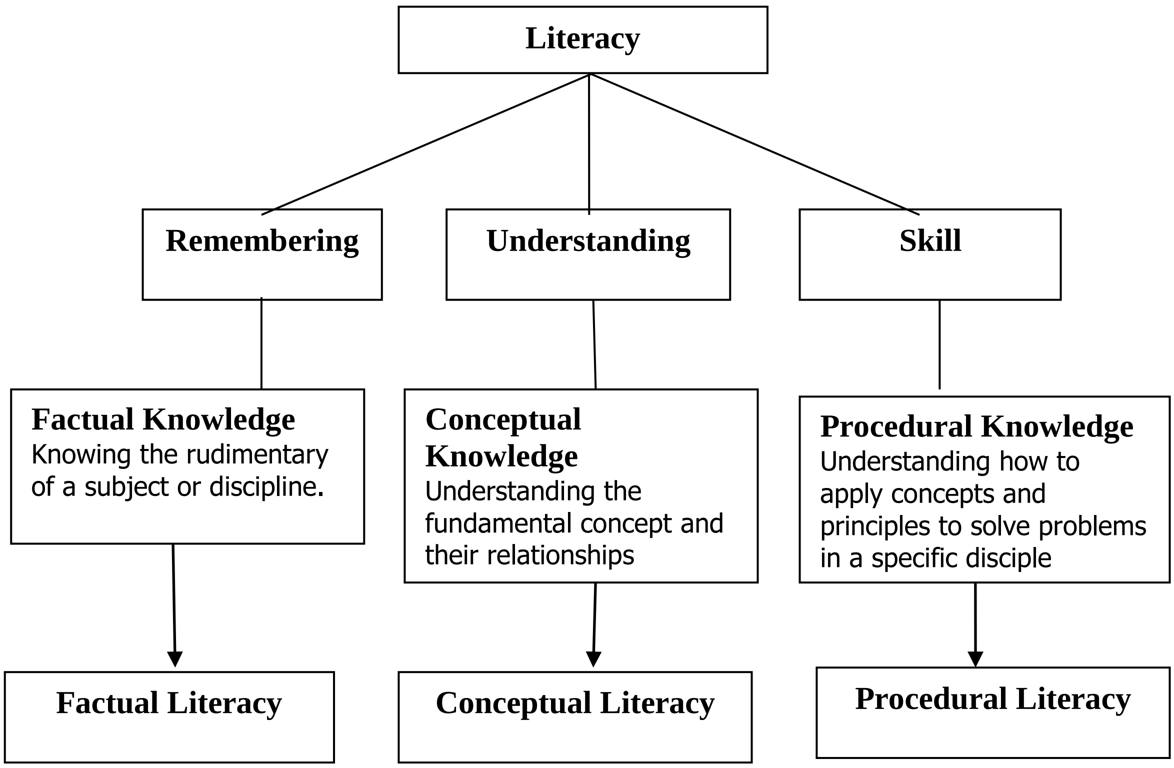

Figure 2: Aspects of literacy and corresponding cognition levels

The next section discusses the conceptualisation of climate change science literacy, culminating in an operational definition of climate change science.

2.2 CONCEPTUALISING CLIMATE CHANGE SCIENCE LITERACY

Before proceeding to define climate change science literacy operationally, an attempt was made to understand the meaning and nature of climate change science.

2.2.1 The Nature of Climate Science

Science is the catchword of our time, yet it is one of the most difficult concepts to define. The difficulty arises from the fact that different people have different perspectives on science. The National Research Council (1996:24) defines science as a human endeavour that deals with and seeks understanding of the natural world. The natural world involves phenomena of the physical world – the world of objects and events. To deal with and understand the natural world involves gaining knowledge of phenomena. Such knowledge is gained by collecting information or data about the phenomenon. It is in this sense that the American Association of Physics Teachers (1999) defines science as a systematic enterprise of gathering knowledge about the world and organising and condensing that knowledge into testable laws and theories.

As a systematic human endeavour, science involves asking questions and defining problems; developing and using models; planning and carrying out investigations; analysing and interpreting data; using mathematics and computational thinking; constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating and communicating information. Through these practices, science seeks to attain three main goals: providing valid, holistic and intelligible descriptions and explanations; discovering solutions to real-world problems; and applying principles and theories from one or multiple domains of science. The first goal entails reaching an understanding of phenomena; the second entails achieving control over the behaviour or functioning of phenomena; and the third entails finding solutions to problems (National Academy of Sciences, 2012; Crowther, Lederman and Lederman, 2005).

The Earth's climate is one of the complex interactive natural systems in and on our planet, Earth. It is constituted of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things as well as their subsystems. The IPCC Fifth Assessment Report (IPCC, 2013:1450) defines climate from two perspectives. The first perspective defines climate from a narrow sense while the second perspective defines it from a more rigorous sense. In a narrow sense, climate refers to the average weather. More rigorously, climate refers to the statistical description in terms of the mean and variability of relevant quantities over a period of time, ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables, such as temperature, precipitation and wind. Climate in a broader sense is the state of the atmosphere, including a statistical description, of the climate system. The changes occurring within the system are highly nonlinear – inputs and outputs are not proportional, but rather episodic and abrupt. However, the different types of nonlinearities, how they manifest under various conditions, and whether they reflect a climate system driven by astronomical forcings, by internal feedbacks or by a combination of both, is relatively poorly understood (Rial et al., 2004:11).

Climate science is the analysis of the Earth's climate. Dupigny-Giroux (2008:483) underlines that climate science involves understanding spatial processes, making spatial predictions, and making sound environmental decisions about the climate. It consists of understanding the complexity and interconnectedness of hydrometeorological patterns over space and time; the role that humans exert on, and the ability to act accordingly having understood, climate science; and recognition of bias or change in behaviour due to a deeper appreciation of an issue or concept. The ultimate aim of climate science is to provide reliable explanations for the complex and interconnected processes and patterns over space and time, including the role of anthropogenic influences on the climate. Like all sciences, climate science is dynamic, which implies that the ways and manner in which scientific work is conducted, the nature of the knowledge that scientists generate, the way and manner in which scientific knowledge is exchanged and how it is applied, are constantly changing.

What was previously considered as 'true' knowledge may no longer be 'true' knowledge in the present context. As a result, scientists are increasingly searching for new knowledge and extending the frontiers of existing knowledge by re-evaluating them. The result of this is the incredible innovations that are found in society today which have produced significant returns in economic growth and sustainable human development, including improvement in health care, transport, agriculture and manufacturing. These innovations have not only created better lives for citizens, but also better citizens.

Taking into account the dynamic nature of science and scientific knowledge (Lederman, Abd-El-Khalick, Bell and Schwartz, 2002; McComans, Almazroa and Clough, 1998), school science education should not focus only on teaching science concepts and content, but also on the development of understandings of the nature of science. This is because scientific literacy about the nature of science is critical for developing knowledge and understanding of the Earth's climate. However, climate analysis does not only require individuals who can apply scientific methods, but also individuals who understand the global environment, the changes occurring in it and the circumstances and conditions that persuade those changes. Based on the fact that no two environments are exactly identical (Yarrow, 2009), climate analysis should involve making sense of spatial patterns of elements and processes and how they cause climate change, as well as their interactions with physical and human systems. It should also include an understanding of the role of technology in society, and the application of technological apparatus to find, retrieve, analyse and use information to understand and address issues relating to global climate change. As a consequence of the geographic nature of climate science, an awareness of the political issues in climate science and how these issues affect each other is also crucial in climate analysis.

In light of the different capabilities required in analysing and understanding the Earth's climate, no one individual can be expected to know everything about climate because climate change science touches on almost all aspects of human endeavour – from ecology to politics (Bhaskar, 2010; Cornell. 2010). As a result, climate analysis is a multidisciplinary human endeavour or, in the terminology of the National Academy of Sciences (2012:2), “a process of collective learning”. As a discipline that involves collective learning, climate analysis requires professionals from different disciplines working as a team and applying scientific methods to provide valid explanations for the processes and changes occurring in climate systems. With the convergence of professionals, each discipline or professional community that comes on board brings along its own language, frameworks, methods and tools. The more disparate the disciplines are from one another, the higher the intensity of the intellectual rifts among their perspectives and the more challenging it becomes for the professionals to become acquainted with the entire viewpoints that are brought into the analysis (Webb, Smith and Worsfold, 2011; Golding, 2009; Nissani, 1997). According to Moser (2010), the multiple disciplinary nature of climate change science is located in some features of climate change, such as the invisibility of the causes of climate change, distant impacts of climate change, a lack of immediate and direct experience of climate change, and a lack of gratification for initiating mitigation action, and the disbelief that humans can influence the global climate. Other features include the complexity and uncertainty of climate science, inadequate signals, indicating the need for change, and perceptual limits and self-interest in developing awareness about climate change. These factors account for the difficulty in synthesising multiple disciplinary viewpoints to arrive at a common ground or take a collective scientific stance on the Earth’s climate.

Sometimes, natural climate variability occurs on temporal scales that are too trivial to be explained in real quantitative terms. Quantitative analysis, which is rooted in positivism, relies on the philosophical belief that the nature of phenomena can be understood through judgment made on the basis of facts gathered through sense experience. According to Higgs and Smith (2006:3), positivism seeks understanding or ‘truth’ by integrating logic and empiricism. Logic seeks true knowledge through inferences from valid arguments. Empiricism, on the other hand, determines true knowledge by the extent to which the phenomenon in question purports to tell us something about real objective facts. Basically, empiricism upholds that true knowledge comes from experience. At times, climatic processes such as the changes occurring within the climatic systems do not represent the features of the entire system and therefore cannot be experienced and described with exactness. In situations like this, scientists resort to models such as the Atmosphere–Ocean General Circulation Models (AOGCMs), Earth System Models (ESMs) and Regional Climate Models (RCMs), to enable an analysis of the response of the climate system to natural and anthropogenic forcings, to predict seasonal to decadal time scales and to project future climate patterns. But, where climate variability is still too trivial for modelling, scientists opt for the parameterisation technique, in which they average the known properties of the system elements and their processes on far larger scales (Edwards, 2011; Jin and Liang, 2006).

As an evolving science, climate science has made many important advances in the past four decades. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2013) attributes the advances to direct measurements and remote sensing from satellites and other platforms, as well as paleoclimate reconstructions recording as far back as millions of years. These advances provide a more comprehensive view of the variability and long-term changes in the atmosphere, the ocean, the cryosphere and the land surface. Despite advances in climate science, general consensus on the nature of climate change still evades climate scientists. There still is a range of plausible projections for future global and regional climate that are specific to some climatic variables and their spatial and temporal scales. When scientists make projections about the climate, they make choices about data and models as well as choices about the processes to include and those to leave out of the analysis. Yet in some instances, the choices scientists make become sources of disagreement and uncertainty (IPCC, 2013; Ingwesen et al, 2013; Van der Sluijs, 2012). According to the IPCC (2013:123), the disagreements among scientists are usually resolved through further scientific inquiry into the sources of the disagreement, but in some cases scientists could reach a consensus view on some issues including the meaning, causes, effects and solutions of climate changes. For now uncertainty is a feature of climate science.

2.2.2 Meaning and Scope of Climate Change Science

Climate change is one of the most widely discussed ecological crises among scientists and policymakers, yet there is controversy among scientists on the actual meaning of climate change, leading to many different definitions of climate change in the literature. To gain a broader view of climate change, it is necessary to explore the perspectives of some individual scientists and some international organisations on the meaning of climate change. One of the earliest definitions of climate change was offered by Mitchell et al. (1966), who define climate change as all forms of climatic inconsistency, irrespective of their statistical nature or physical cause. In terms of this definition, climate change includes any unpredictable change in global climate patterns, notwithstanding the magnitude or source of the change. This perspective is different from that of Agrafioti (2011), who defines climate change as a long-term change in the statistical distribution of weather patterns over periods of time, ranging from decades to millions of years. Agrafioti (2011) also refers to changes in the average weather conditions or a change in the distribution of weather events with respect to average weather events that may be limited to a specific region or may occur across the entire earth.

For Hellmuth, Moorhead, Thomas and Williams (2007:4), climate change is the longer term trends in average temperature or rainfall or in climatic variability itself, and often trends resulting wholly or in part from human activities, notably global warming due to the burning of fossil fuels. This definition refers to any longer term trend in average temperature or rainfall as climate change and identifies anthropogenic global warming as the key factor of climate change. For Gregory et al. (2009), climate change refers to variations in the Earth’s climates over different timescales relative to variability or average weather from decades to millions of years. These changes evolve due to variations from within the earth-atmosphere system, from extra-terrestrial processes, or from human activities such as greenhouse gas emissions and land-use changes, resulting in an average rise in air temperature, commonly referred to as global warming. The extra-terrestrial factors include variability of solar radiation and earth-sun geometry. Earth-sun geometry means the difference in the earth’s orbital shape, and the tilt and wobbling of the earth's axis of rotation. Gregory et al. (2009) contend that climate change is caused by the combined effects of anthropogenic greenhouse emissions and non-terrestrial factors.

The Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) offer two technical but opposing definitions of climate change. The obligation of the IPCC is to prepare assessments based on available scientific information on all aspects of climate change and its impacts and to formulate realistic solutions for climate change. Conversely, the UNFCCC, as an international environmental agreement, has the obligation to stabilise greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system. It is possible that these two different obligations could produce different scientific viewpoints, which might introduce controversy into understanding the concept of climate change.

A study of related literature and policy/mission statements illuminates broadly differing scientific perspectives on the phenomenon of climate change. In IPCC (2014:4) terminology, climate change refers to a change in the state of the climate that can be identified (e.g. based on using statistical tests) by changes in the mean and/or the variability of its properties that persists for an extended period – decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycle, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Conversely, in UNFCCC (United Nations, 1992:3) terminology, climate change means a change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Both the IPCC and UNFCCC recognise the role of internal and external forcings on the global climate, but they differ on the criterion used for distinguishing change from variability. The IPCC contends that, for a climatic event to qualify as climate change, it has to occur persistently, whereas the UNFCCC insists that any form of variability in the climate pattern qualifies ‘immediately’ as climate change. However, for the World Meteorological Organisation (WMO), the occurrence of an unusual climatic event, such as a series of severe tropical cyclones or protracted absence of rainfall that had never occurred before in an area, could be regarded as part of a natural climate variability event if it did not recur within the next thirty years from the time of its last occurrence. It is only when climatic events occur persistently in the context of regional climate parameters that it can be described as a ‘change’ in climate pattern (WMO, 2014). This clearly reflects a definite difference in how climate change is perceived by significant scientific organisations working in this field and could influence how this concept is understood by teachers and how it is taught in schools.

The United States Department of Education (2005:1) defines science as a human endeavour that involves observing, classifying, predicting, testing and drawing conclusion about the nature of phenomena. Science seeks explanations about phenomena by asking basic questions, such as: How does the world work? How did the world come to be? What was the world like in the past? What it like is now? What will it be like in the future? (NRC, 1996). Climate change science is an attempt to understand the nature of the climate system and its recent changes, including the causes, impacts/consequences of these changes on natural and human systems, and their solutions (National Aeronautics and Space Administration, 2014; IPCC, 2014, 2013; NOAA, 2011; Bhaskar, 2010; Cornell, 2010). Different researchers provide different models of the nature of climate change science in an effort to describe the domain of climate change science.

Bryant (1997) provides a model that categorises climate change science into four domains, namely climate history; processes; change; and impacts. Climate history of the Earth consists of the evolution of the Earth’s climate, climate differences on Earth and other planets, planetary greenhouse gases, the climate record of the Earth, and the nature of present records of climate change. Processes consist of climatic processes, scales of heat and transfers in the atmosphere, and the role of oceans. Change encompasses scales of climate change from the Pleistocene to modern times, causes of climate change, and human effects on climate change. Impacts comprise the health impacts of climate change and ecosystem impacts of climate change.

Although Bryant's model touches on climatic process and the impacts of climate change, it does not make any mention of climate change mitigation and adaptation that may offer solutions to climate change, thereby making this model unsuitable to address the research questions of this study.

Houghton (2004) provides a model that identifies twelve topic areas that constitute climate change science. The topics include global warming and climate change, greenhouse effect, greenhouse gases, climates of the past, climate modelling, climate change in the 21st century and beyond, the impacts of climate change, and the need for concern about climate change. Others topics are uncertainty characterising climate change science, strategies to slow and stabilise climate change, future energy use and transport, and the global village. Houghton's model dwells exhaustively on climatic process, the impacts of climate change, and climate change mitigation, whereas the probable causes of climate change and climate change adaptation are obscured.

Another attempt to define the scope of climate change is made by Hardy (2005), who identifies three content areas or domains of climate change science. The first domain is climate change – past, present and future – consisting of Earth and the greenhouse effect, past climate change, present climate change, and future climate changes. The second domain focuses on the ecological effects of climate change, comprising effects of climate change on freshwater systems, effects of climate change on terrestrial ecosystems, climate change and agriculture, and climate change and the marine environment. The third domain is concerned with the human dimensions of climate change – the impacts of climate change on human settlement and infrastructure, human health, mitigation – reducing the impacts, and the policy, politics and economics of climate change. Hardy's model is more comprehensive in the sense that it includes measures to reduce the impacts of climate change on natural and human systems, which Bryant's model does not provide and which Houghton's model does not address adequately. Hardy's (2005) model touches on climate change, highlighting climate history and climatic processes, effects of climate change, and human dimensions of climate change.

Recent arguments in science education propose that school science should pay more attention to teaching the nature of science and its social practices (Osborne, Collins, Ratcliffe, Millar and Duschl, 2003:692). Accordingly, UNESCO (2009a:3) provides a set of content topics that can be taught to enhance people's knowledge and understanding of climate change. These entail:

- "Making clear distinctions between different scientific concepts and processes associated with climate change; knowledge of, and abilities to distinguish between, certainties, uncertainties, projections and risks associated with climate change;
- Knowledge of the history and interrelated causes of climate change (which include technical, scientific, ecological and social dimensions, economic dimensions, and political dimensions);
- Knowledge of mitigation and adaptation practices that can contribute to wider social transformation towards sustainability, including abilities to participate in such practices; knowledge of consequences and what is being learned about mitigation and adaptation to climate change;
- Good understanding of the time-space dynamics of climate change, including the delayed consequences that current greenhouse gas emissions hold in store for the quality of life, security and development options of future generations;
- Understanding of different interests that shape different responses to climate change (e.g. business interests, consumer interests, farmers' interests, political interests, future generations' interests, etc.) and abilities to critically judge the validity of these interests in relation to the public good;
- Critical media literacy to address the causes of overconsumption and develop capacity to make better lifestyle choices and to participate in climate change solutions."

These content topics include the essential elements of climate change science: climatic processes and probable causes of climate change, climate change impacts/consequences, and climate change solutions. These three basic elements are discussed below.

2.2.3 Elements of Climate Change Science

2.2.3.1 Climatic Processes and Causes of Climate Change

The climate system is composed of subsystems that are all interconnected and open, allowing fluxes of mass, energy and momentum from and to each other. These fluxes eventually cycle through so that outputs re-enter the system to become inputs, producing negative or positive feedback to the climate system. The subsystems include the atmosphere, biosphere, hydrosphere and geosphere, the anthrosphere (e.g. economy, society, culture), and their complex interactions. Each subsystem affects the response of every other subsystem and of the climate as a whole. Incoming solar radiation which is balanced by radiation dissipated into space plays and important role in climate system processes and is the main sources of nonlinear behaviour of the climate system, and of course the main sources of uncertainty in accurately predicting future impacts of global climate change (Loubere, 2012; IPCC, 2007; Kiehl and Trenberth 1997; Rial et al., 2004; Kabat et al., 2003).

Climate change is the most disturbing environmental change the Earth has witnessed (International Institute for Sustainable Development, 2013; IPCC, 2013; Oxfam, 2013; National Research Council, 2011). Climate change in this century is caused mainly by global warming. The term 'global warming' is the increase in average temperature of the Earth's atmosphere, mainly due to increases in the concentration of carbon dioxide and other greenhouse gases The enhanced greenhouse effect provides a credible explanation of the link between rising greenhouse gas concentrations and a warming world. Greenhouse gases, as defined by Leggett (1990:14), are gases that cause infrared radiation to be retained in the atmosphere, resulting in the warming of the Earth's surface and the lower part of the atmosphere. Their main anthropogenic sources are carbon dioxide (fossil fuel burning, deforestation and land use changes, and cement manufacturing), methane (emanating from rice paddy cultivation, ruminants, including cows and sheep, biomass burning and decay, release from fossil fuel production), chlorofluorocarbons (from sources such as manufacturing of solvents, refrigerants, aerosol spray propellants, foam packaging), nitrous oxide (emanating from fertilisers, fossil fuel burning, land conversion for agriculture), precursor gases (involved in the ozone and methane chemistry), nitrogen oxides (emanating from fossil fuel burning), non-methane hydrocarbons (arising from the evaporation of liquid fuels and solvents), and carbon monoxide (arising from fossil fuel and biomass burning) (IPCC, 2013, 2012, 2011; NOAA, 2013; Hansen, Sato, Kharecha and Von Schuckmann, 2011; European Union Climate Change Expert Group, 2008).

The account provided in this section indicates that global climate change may continue for a long time in the future. Much of the changes that have occurred in the present century are attributed mainly to the net production of carbon dioxide, despite the fact that water vapour is the most abundant and most important greenhouse gas in the atmosphere. In an attempt to understand the past and present climate and predict future climates, scientists have resorted to modelling. Despite progress in scientific analysis of the Earth's climate, there is a lot more that we do not know about the processes and causes of global climate change because of the uncertainty of the climate system (IPCC, 2014, 2013, National Research Council, 2011). The next section discusses the impact of climate change. It begins with an explanation of the concept 'vulnerability' and proceeds to South Africa's vulnerability to climate change, and the overall impacts of climate change.

2.2.3.2 Climate Change Impacts

Different researchers and organisations have discussed current and projected impacts of climate change (Desanker, 2010; Tadesse, 2010; Institute for Security Studies, 2010; Convention on Biological Diversity, 2009; Food and Agricultural Organisation, 2007). However, the most recent assessment report of the Intergovernmental Panel on Climate change (IPCC, 2013) provides a current account of the indicators and impacts of global climate change. According to the IPCC (2013:135-136), some phenomena are visible indications of climate change. These include higher maximum temperatures and more hot days, higher minimum temperatures and fewer cold days, heat waves, precipitation extremes, drought and dryness, and increases in extreme sea level. Other indicators include ocean acidification and rapid sea ice loss. The extent to which a person, country or region is affected by climate change depends largely on their exposure, vulnerability and resilience.

The terms exposure, vulnerability and resilience in relation to climate change are sometimes confusing, but the IPCC (2013:3) makes a distinction between them. The term exposure refers to the presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social or cultural assets in places that could be adversely affected. Vulnerability refers to the propensity or predisposition to be adversely affected, whereas resilience is the capacity of a social-ecological system to cope with a hazardous event or disturbance, responding or reorganising in ways that maintain its essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation. The relationship between exposure, vulnerability and resilience is that a region's exposure to climate change might increase its propensity to be adversely affected, although the extent to which the region is affected depends on its resilience. According to the IPCC (2013), a person's exposure and vulnerability to climate change is influenced by age, pre-existing health status, level of outdoor activity, socioeconomic factors including poverty and social isolation, access to and use of cooling, and the physiological and behavioural adaptation of the population. Others include urban heat island effects and urban infrastructure.

Climate change is already affecting systems, sectors and regions in many different ways. Some are more likely to be especially affected than others. Pertaining to natural systems and sectors, the most vulnerable are ecosystems, particularly tundra, boreal forests, mountains, Mediterranean-type ecosystems, mangroves and salt marshes, coral reefs and sea ice biomes; low-lying coasts, due to the threat of sea-level rise; and water resources in low latitudes, due to decrease in rainfall and higher rates of evaporation and transpiration. Other systems and sectors most vulnerable are agriculture in low latitudes due to reduced water availability; and human health, especially in areas with low adaptive capacity (IPCC, 2013; Parry, Canziani and Palutikof, 2008).

Climate change also affects human systems through a decrease in water availability in moist tropics and at high latitudes and increased droughts in mid-latitudes and semi-arid latitudes. Due to these conditions over than a billion people on our planet face water stress (IPCC, 2014, 2007 Morrison, Morikawa, Murphy and Schulte, 2009). At the moment, many species are at risk of extinction. There is an increase in coral bleaching and widespread coral mortality, in addition to increases in species range shifts and wild fire risk. Low latitudes are already experiencing decreases in cereal production, and high and mid-latitudes are experiencing increases in cereal production. Continued climate change will lead to decreases in cereal production worldwide. Coasts and coastal infrastructure are damaged from floods and storms, and over 30% of coastal wetland has been lost globally (IPCC, 2014, 2007). In addition, millions of people are at risk of coastal flooding each year. The burden of malnutrition, diarrheal, cardio-respiratory and infectious diseases is increasing, in addition to increased morbidity and mortality due to heatwaves, floods and droughts. There also are changes in the distribution of some disease vectors. The impact of climate change on health imposes a substantial burden on health services globally. Pertaining to regions, the most affected by climate change are the Arctic, Africa, the Small Islands States and Asian mega-deltas based on observed and projected impacts (IPCC, 2013; Parry, Canziani and Palutikof, 2008).

Models of the effects of climate change on society are often framed as a chain of causation (Pfister, Kwadijk, Musy, Bronstert and Hoffman, 2004). The first chain of the effects of climate change is the biophysical impact on agricultural production or on the outbreaks of diseases or epizootics. These first-order effects may have second-order impacts on the prices of food or raw materials, which may later have serious consequences for the wider economy and society (third-order impacts). The further people move away from the first-order impacts, the greater the complexity of the factors masking the climatic effects. The reason is that it is easier to investigate the effects of short-term (annual and perennial) effects of climate change than to investigate the long-term effects, which may fail to account for modifications in the economic, institutional and environmental settings over time.

2.2.3.3 Climate Change Responses

Scientific evidence suggests that climate change drivers will not cease anytime soon (Carrasco, 2014; IPCC, 2013). Deciding on the best course of action to respond to an ecological crisis that is not likely to stop anytime soon raises fundamental questions on its actual causes, effects and consequences, including the nature of the risk people are facing. Reducing emissions of carbon dioxide, methane, chlorofluorocarbons and nitrous oxide must be the focus of any attempt to curb global warming, as these gases account for about 90% of the enhancement of the greenhouse effect that has already occurred. However, predicting the manner in which greenhouse emissions will affect the atmospheric composition is not a simple matter. Emission rates, whether from anthropogenic or natural sources, are uncertain, and the physical, chemical and biological processes that remove greenhouse gases from the atmosphere are poorly understood. Also, the manner in which the production and removal of the gases may be affected by future changes in the composition of the atmosphere and in the climate is uncertain. The answers to these questions still remain highly uncertain and contested. Decision making rests on two broad perspectives – take action to slow down the rate of climate change, or ‘wait and see’ , (Blowers and Hinchliffe, 2003).

For some observers, the scientific claims about the future climate risks are already enough and beg urgent and drastic precautionary measures in order to restore thermal equilibrium to the planet. These measures include reducing emissions of greenhouse gases and taking action such as building sea walls to adapt to anticipate climate change. For others, the contested nature of aspects of the science suggest a wait and see approach, to respond slowly by adapting to or coping with climate change impacts as they unfold. These two perspectives are at the heart of the political tension and uncertainties among nations and other stakeholders. Both scientific and political uncertainties are connected in various ways and both contribute to making the task of mitigation and adaptation complex and difficult. For example, science may provide evidence that climate change is real, but political will is required to communicate scientific evidence to the population. It will also require political will to initiate and implement mitigation and adaptation action. Conversely, a political will without sound scientific evidence will not be productive in promoting mitigation and adaptation. While science strives to make uncertainties certain, political will is necessary to translate scientific evidence into action (Giddens, 2008; Selin and Vandeveer, 2006).

Peak (2003, in Blowers and Hinchliffe, 2003) identifies three main options that humans can initiate to manage climate change, namely Option 1: Do little or nothing (inactive response); Option 2: Adaptation (reactive and proactive responses); and Option 3: Mitigation (proactive responses). Another possible option is a combination of these three. The ‘do little or nothing’ option, as described by Peak (2003, in Blowers and Hinchliffe, 2003), is underpinned by the logic that there is no strong evidence that the decision can always be taken to adapt and or mitigate climate change at any future stage. We can continue on our business as usual global emissions pathway and simply wait and see:

(i) if emissions actually grow this way; and
(ii) the scale of damages that unfold.

Owing to a lack of certainty in some of the claims scientists make about climate change, the wait-and-see option is logical, as the claims are not strong enough to make people worry now and for any action to be taken immediate (Carter, 2010); Scafetta, 2010; Hillerbrand and Ghil; 2008; Lupo; 2008). As Houghton (2004:227) highlights, “What we should do is to obtain as quickly as possible, through appropriate research programmes, much more precise information about the future climate changes and its impacts. We would then, so the argument goes, be in much better position to decide on relevant action.” This statement further clarifies the importance of convincing people through valid and visible evidence of climate change, which would require collaboration between science and politics. The relevant action therefore would be to pursue adaptation and mitigation concurrently.

Adaptation, as defined by Pielke (1998), involves adjustment to the impacts of climate change. Adjustment to climate change is based on the logic that the climate systems take several hundred years to work themselves through. Even if greenhouse gas emissions were to fall suddenly and dramatically today, the earth’s climate would continue to change for centuries. In IPCC terminology, adaptation refers to an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2013). Adaptation to climate change is a complex activity that requires adaptive and mathematical skills. According to Pruneau, Khattabi and Demers (2010), adaptive skills for climate change encompass carrying out vulnerability analysis, predicting and managing risks, creative problem-solving as well as scientific, technical and mathematical skills. These skills are relevant for understanding the nature of climate change.

There are multiple options available to human society for an adaptive response to climate change, ranging from technological (for example sea defences) through behavioural (for example altered food and recreational choices), to managerial (for example altered farm practices) and to policy (for example planning regulations). Although these options exist, there are formidable environmental, economic, informational, social, attitudinal and behavioural barriers to the implementation of adaptation. Non-climate stresses such as current climate hazards, poverty and unequal access to resources, food insecurity, trends in economic globalisation, conflict and the incidence of diseases such as HIV/AIDS increase vulnerability to climate change by reducing resilience and can also reduce adaptive capacity owing to resource deployment to competing needs.

Mitigation, as described by Anderson (2010), refers to interventions aimed to reduce greenhouse gas (GHG) concentrations by cutting down GHG emissions or moving carbon out of the atmosphere. It involves any human interventions aimed to reduce the source or enhance the sinks of greenhouse gases. This option involves actions ranging from investment in clean energies to forest conservation. Mitigation involves any human interventions to reduce the source or enhance the sinks of greenhouse gases; generating electricity from renewable sources of energy instead of fossil fuels and saving energy wherever possible; and planting forests to sequester carbon in the form of woody biomass. Mitigation, according to the IPCC (2013), includes anthropogenic interventions implemented to reduce the sources or enhance the sinks of greenhouse gases, and adaptation/adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects that moderate harm or exploit beneficial opportunities.

Klein et al (2007) believe that the benefits of mitigation carried out today will be evident in several decades because of the long residence time of greenhouse gases in the atmosphere (ancillary benefits such as reduced air pollution are possible in the near term), whereas many adaptation measures would be effective immediately and yield benefits by reducing vulnerability to climate variability. The concentration of carbon dioxide in the atmosphere can be reduced through sequestration. Carbon sequestration refers to processes that remove carbon dioxide from the atmosphere and retain it, for some time, in carbon sinks, for example trees (IPCC, 2013).

The Kyoto Protocol is an international instrument that urges countries to help to stabilise the concentration of carbon dioxide in the atmosphere. This can be done through domestic and offshore measures. Domestic measures involve reducing emissions locally by reducing traffic emissions through boosting public transport, reducing electricity consumption in households, offices, schools and factories via energy efficiency measures, and better designs of all forms of energy products, processes and systems. These actions could work well in less developed countries where infrastructure and technology are inadequate to pursue extensive mitigation. Offshore measures, on the other hand, provide a way for industrialised countries, under certain conditions, to trade emissions permits or to obtain credit for emission reductions that are achieved through overseas sustainable development projects (UNFCCC, 2011; Blowers and Hinchliffe, 2003; United Nations, 1992).

The Kyoto Protocol also came up with three key mechanisms to provide opportunities for countries to reduce the economic cost of emissions reduction: Emissions Trading (ET), also known as the Carbon Market (CM), Clean Development Mechanism (CDM), and joint Implementation (JI). Emissions trading (ET), also referred to as the carbon market (CM), is a key tool in reducing emissions worldwide by allowing industrialised countries to balance their greenhouse gas books by buying and selling greenhouse gas permits. The clean development mechanism (CDM) involves investment in sustainable development projects that reduce emissions in developing countries. Joint implementation involves reducing emissions or increasing removal by sinks in the territories of other industrialised countries, especially countries with economies in transition where there is greater opportunity for cutting emissions at reduced cost (UNFCCC, 2011; Gillenwater and Seres, 2011; Liverman, 2008; Houghton, 2004).

It is believed that the media can shape and affect science and policy discourse as well as public understanding of and action on climate change. The newspapers, television and radio broadcasts, the Internet and mobile phones can form and transform people's behaviour and attitudes to climate change. The opinions of journalists can persuade policymakers to develop effective and efficient climate change response policies and strategies. However, in most parts of the world, journalists struggle to report effectively on climate change due to a lack of training, unsupportive editors, and weak outreach from domestic policymakers. In addition, media coverage of climate change still occupies only a small proportion of total media reporting relative to the complexity of climate change (Boykoff and Roberts, 2007).

2.2.4 Operational Definition of Climate Change Science Literacy

The attempt to provide an operational definition of climate change science literacy would require an effort to identify and categorise the relevant concepts that constitute climate change science in Figure 3 and the subdomains of climate change science in Figure 4. Figure 3 shows the key concepts that are linked to each subdomain of climate change science identified through the review of literature.

Figure 3 reveals that the concepts in Subdomain A relate to climatic processes, including probable causes of climate change. Concepts in Subdomain B relate to the impacts of climate change. Concepts in Subdomain C relate to climate change responses.

Subdomain A The Earth's atmosphere, climate, weather, greenhouse gases, greenhouse effect, temperature increase, climate system, carbon dioxide emissions, climate variability, climate change, extremes events, past and present climate, future climate, natural causes, anthropogenic causes.
Subdomain B Effects, impacts, consequences, natural systems, human systems, water stress, food insecurity, conflict, natural resources degradation, sea level rise, glacier melt, rising global temperature, increased ocean acidity, ecosystems deterioration, land degradation, disease outbreak, developed countries, developing countries, local communities, regional impacts, global impacts
Subdomain C Vulnerability, risk, adaptive capacity, mitigation, adaptation, business as usual, climate policies, local participation, the media, awareness, carbon sequestration, Kyoto protocol, Kyoto mechanisms.

Figure 3: Concepts linked to Climate Change Science

The three subdomains constitute climate change science, as illustrated in Figure 4.

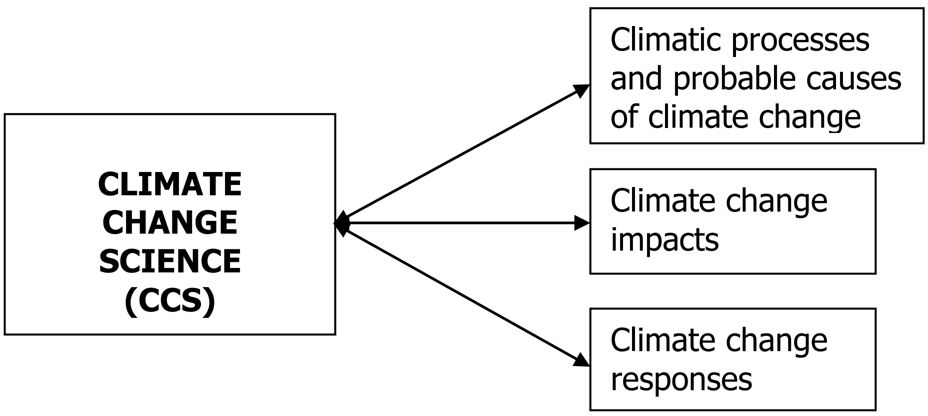

Figure 4: Subdomains of Climate Change Science

The scope of these three subdomains is defined below based on IPCC, 2014, 2013, 2007), Hardy (2005), Houghton (2004) and Bryant (1997) perspectives on climate change science discussed in Section 2.3.2.

Climatic processes and probable causes of climate change refer to complex processes occurring within the Earth's climate systems as a result of natural and anthropogenic factors that give rise to global warming and climate change. Some of the relevant content topics in this subdomain are:

a) The Earth's climate systems
b) Global warming
c) Natural/anthropogenic causes of climate change
d) Global CO_2 emissions and future climates
e) The nature of climate science

Climate change impact refers to the influences, effects/consequences of climate change on natural and human systems. The relevant content topics include:

a) Evidence of climate change in natural/ human systems
b) Climate change and water availability
c) Vulnerability of sub-Saharan Africa
d) Effect of climate change in developing countries
e) Global effects of climate change

Climate change responses refer to all measures aimed at reducing the causes of climate change and helping communities to adapt to its consequences. The relevant content topics include:

a) Stabilisation of global carbon production
b) Rural people and their adaptation to climate change
c) Implementation of climate change polices
d) Mitigation and adaptation options for developing countries, if global warming continues for centuries
e) Climate change response instruments

These three subdomains constitute Part C of the measurement instrument for the assessment of climate change pedagogical literacy. The process of instrumentation is discussed in Chapter 3.
The three subdomains of climate change science are then linked with the elements of literacy to provide a model of the elements of climate change science literacy shown in Figure 5.

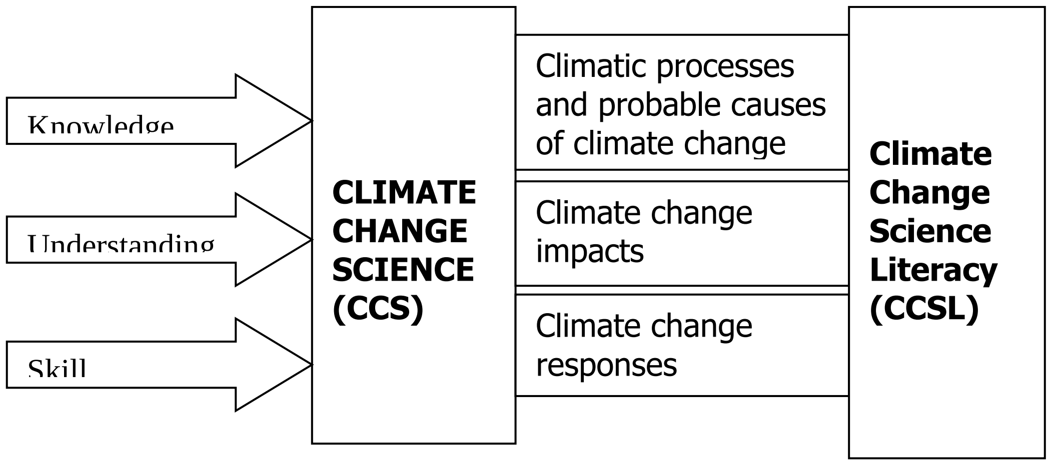

Figure 5: Elements of Climate Change Science Literacy

In the light of the elements in Figure 5, climate change science literacy (CCSL) incorporates literacy in climatic processes and probable causes of climate change, literacy in climate change impacts, and literacy in climate change responses. With this understanding, climate change science literacy is defined in this study as knowledge, understanding and skill for solving problems involving climatic processes and probable causes of climate change, climate change impacts and climate change responses.

With CCSL defined operationally, this study asks:

How literate are geography teachers in the Western Cape in climate change science?

To investigate this question thoroughly, the following sub-research questions were investigated:

- How literate are geography teachers in the Western Cape in climatic processes and probable causes of climate change?
- How literate are geography teachers in the Western Cape in climate change impacts?
- How literate are geography teachers in the Western Cape in climate change responses?

Having located the first main research question and subsidiary research questions, the next attempt is to understanding the different approaches and methods used by other researchers to assess literacy in climate change.

2.2.5 Methodology for Assessing Climate Change Science Literacy

There is a growing interest in research on teacher knowledge of climate change in the last decade; however, different researchers employ different models of climate change science and different research paradigms and methods of investigation. Ochieng and Koske (2013) examined the level of climate change awareness and perceptions among teachers in Kenya using descriptive survey design. The participants were 100 primary school teachers from 20 schools, including public and private schools in Kisumu Municipality. The sample was selected using multistage stratified sampling to ensure representativeness by zone. Data was collected with a semi-structured questionnaire. Awareness level was categorised on a Likert scale as Low (1-2), Medium (2.01-3.99) and High (4-5). The results show a medium level of awareness of climate change among the teachers, but there was a gap in their knowledge and understanding of climate change. An overwhelming 93.3% of the teachers perceived climate change as an issue of global concern. Based on these results, Ochieng and Koske (2013) concluded that the level of climate change awareness among primary school teachers in Kisumu Municipality, Kenya was significantly high, but there were significant gaps in their knowledge that need to be addressed.

An investigation of how student teachers understand climate change was conducted by Ratinen, Viiri and Lehesvuori (2013) based on communication in the teaching session and pre- and post-concept mapping using descriptive and prospective case study design. The participants were 20 second-year primary school student teachers who had not studied science before at the university. The participants were exposed to four inquiry-based science sessions – physics, chemistry, biology and geography. Data was collected after these sessions were completed. The essay component of the assessment provided insight into the participants' perceptions of climate change based on their spontaneous responses. The responses were analysed and classified into concept categories and, based on these, the researcher produced two concept maps. The science sessions were also videoed and analysed to understand the communication that took place during the sessions. The analysis of the student teachers' post-conceptualisation of climate change showed that their conceptualisation of climate change varied. In addition, they believed that ozone depletion causes global warming but some of them could understand that water vapour, methane, ozone, carbon dioxide and chlorofluorocarbons are also greenhouse gases.

Nwankwo and Onachukwu (2012) used non-experimental survey design to explore teachers' awareness of the causes and effects of climate change and their classroom management strategies. The samples were 145 secondary schools in Anambra State, Nigeria, selected using probability sampling methods. The participants were 1 450 teachers. Like Boon's study, Nwankwo and Onachukwu collected data using a structured questionnaire. The collected data was analysed using descriptive statistics: means and t-test. The results of the descriptive analysis revealed that the participants had poor knowledge of the causes and effects of climate change. Also, the participants did not apply a variety of classroom management strategies. The results of inferential analysis reveal a significant difference in the mean scores of the teachers on their level of awareness of the causes of climate change based on their school location. No significant difference was found in their level of awareness of the effects of climate change. In addition, no significant difference was found in the mean scores of male and female teachers on the causes of climate change and effects of climate change.

In a study of Omani pre-service teachers' views on global warming, Ambusaidi, Boyes, Stanisstreet and Taylor (2012) found that the majority of the teachers believed that global warming and climate change were occurring now and they were concerned about them. They were also aware of the measures humans can take to mitigate and adapt to climate change, such as use of public transport and more fuel efficient cars, but they lacked the willingness to implement such measures. This finding does not agree with Ekpo and Ekpo's (2011) assessment of the level of climate change awareness among secondary school teachers in Calabar Municipality, Nigeria, which shows that the teachers' level of climate change awareness was significantly low, particularly their awareness of the causes, effects and solutions of climate change. These findings are consistent with those of Olufemi, Obianuju and Oyenike (2014) and Papadimitirou (2004), who found that teachers and learners hold misconceptions about climate change.

Boon (2010) examined, compared and contrasted secondary students with final-year pre-service teachers in Queensland, Australia. The study focused on knowledge of the causes and consequences of climate change, views about climate change and the role played by the ozone layer, the sources of the ideas, the importance of climate change, and solutions to climate change. The participants were 310 Grade 10 learners from four state schools selected at random, and 107 final-year pre-service teachers comprising 56 primary education specialists, 32 early childhood education specialists and 19 secondary education specialists; among them eight cited science or studies of the environment and society as their specialisation. The participants were not required to reveal their identity on the questionnaire. They had the right to choose whether to stay in the study or not and to leave any questions that they did not want to answer. The results revealed that 25% of the pre-service teachers and 13.9% of the secondary learners understood heat as the main cause of the greenhouse effect, which is a misconception. Only a few teachers and learners knew, besides carbon dioxide, that CFS, nitrous oxides, methane and water vapour are greenhouse gases; 22.7% of the teachers and 13% of the secondary learners confused the role of the ozone layer with the greenhouse effect.

Boon (2010) also found that a difference existed between teacher group and learner group (61.4% of pre-service teachers and 5.8% of learners) on appreciation of the relationship between greenhouse effect and climate change, in favour of the teachers. The two groups performed equally well on the impacts of the greenhouse effect on human activity. Boon (2010) concluded that both the secondary learners and pre-service teachers, including those secondary specialists in science and environmental studies, showed poor knowledge and understanding of climate change. In the light of these results, Boon (2010) emphasised the need for prospective teachers to begin their teaching careers with a clear understanding of the fundamentals of climate change science.

Emerging from the reviewed studies is that they all involved analysis of data collected with questionnaire from a large samples which necessitated the survey research design. In addition, the majority of the studies found that teachers are not knowledgeable of climate change.

2.3 CONCEPTUALISING CLIMATE CHANGE PEDAGOGICAL LITERACY

It would be difficult to formulate an operational definition of climate change pedagogical literacy without first understanding the concept of kinds of knowledge base teachers require for effective teaching, and their implications in the content of Climate Change Education (CCE).

2.3.1 Meaning and Nature of Pedagogy

The term ‘pedagogy’ is a difficult concept to define with few words because it involves almost everything that has to do with curriculum. Pedagogy is the practice of teaching framed and informed by a shared and structured body of knowledge that comprises experience, evidence, understanding moral purpose and shared transparent values (Pollard, 2010:5). Curriculum on the other hand is a way of structuring learning experiences, an organised programme of activities, opportunities and interactions that is usually derived from some explicit or implicit ideological or theoretical understanding about how children learn (Stephen, 2006:3). The views of Pollard (2010) and Stephen (2006) portray that pedagogy is not just about teaching of content to learners rather it involves the philosophies that define the activities of the teacher and the learners in a learning situation. As a philosophy of teaching, pedagogy defines, in the context of the society, the kinds of aims/objectives to be attained and how these can be attained. Thus, good pedagogy should facilitate the attainment educational goal. According to Dembo (1988:366) good pedagogy involves presenting the child with situations in which he himself experiments, in the broadest sense of the term – trying things out to see what happens, manipulating things, manipulating symbols, posing questions, and seeking his own answers, reconciling what he finds at one time with what he finds at another, comparing his findings with those of other children. The pedagogy like the one described by Dembo (1988) could be relevant to attain the aim of climate change education.

2.3.2 The Scope of Climate Change Pedagogy

Following Pollard's (2010) of pedagogy and Stephen's (2006) definition of curriculum, Climate Change Education is concerned with the philosophy that defines aims/objectives of learning about climate change and how these aims and objectives can be attained. These two components of Climate Change Education are elaborated below.

2.3.2.1 The Aim and Significance of Climate Change Education

The past three decades have witnessed a plethora of international seminars and conferences on environment and related challenges. Among the issues that dominated the conferences are education and environment, and recently climate change education. Some of these include the 1972 Stockholm Conference, the 1977 Tblisi Conference, the 1987 World Commission on Environment and Development, the 1990 World Summit for Children and the 1992 Rio de Janeiro Conference. Other prominent international gatherings include the 2002 Johannesburg Summit, the 2009 World Conference on Education for Sustainable Development and the 2009 International Seminar on Climate Change Education.

The International Seminar on Climate Change Education was held three months after the Bonn Conference on Climate Change Education. The main objectives of the gathering were as follows:

- Promote the effective integration of climate change education into education programmes and school curricula;
- Mobilise support for teacher training on climate change education;
- Enhance the exchange of experiences and good practices on climate change education among ministries, teachers, practitioners and young people;

- Identify opportunities for using various networks, such as the UNESCO Associated Schools Networks, World Heritage Sites, Biosphere Reserves, and Networks of the International Hydrological Programme, to encourage local field-based education on climate change;
- Identify learning materials and good practices on climate change education and enhance their dissemination via information and communication technologies as well as other means.

These objectives were framed to address the overall aim of climate change education.

Climate change is a post-normal problem (Van der Sluijs, 2012). As a result, climate change education is education aimed at addressing a post-normal problem. Climate change education involves helping people to understand and address the impacts of global warming today, while at the same time encouraging the change in attitudes and behaviour required to act on climate change (UNESCO, 2009). The definition suggests that climate change education does not only aim to develop people's knowledge of the science of climate change, but also to instill environmental consciousness (attitudes, behaviours and values) and develop the skills needed to respond sensibly to climate change. Leger and Pruneau (2012), Hwang, Kim, and Jeng (2000) and Hungerford and Volk (1990) argue that knowledge alone does not guarantee that people will act, although it presupposes the intention to act. For people to act on the environment they must have the competencies to do so. Initiating climate change education in schools will help children and young people to develop the competencies to respond positively to climate-related challenges and to shape and sustain future policies on climate change (UNESCO/UNEP, 2011; Pruneau, Khattabi and Demers, 2010; Chakeredza, Temu, Yaye, Makungwaand Saka, 2009; UNESCO, 2009a; Pruneau and Utzschneider, 2008).

Basically, the aim of climate change education is to develop people's adaptive competencies for climate change. Adaptive competencies for climate change include carrying out vulnerability analysis, predicting and managing risks, creative problem-solving as well as scientific, technical and mathematical skills. Individuals who have competencies to do vulnerability analysis are in a position to determine the extent to which their locality can be harmed by climate change and specific aspects of their livelihood that are more vulnerable. People who are able to identify a problem, propose some pragmatic responses and identify the process and tools required to solve the problem are more likely to adapt to climate change than those who do not. Similarly, people who are capable of assessing a range of options and choosing the best option from them, and are aware of the implications of the choices they have made are more likely to initiate and implement adaptation responses than those who cannot (Utzschneider and Pruneau, 2010; Pruneau et al, 2008).

Besides adaptive competencies such as carrying out vulnerability analysis, problem solving and decision making, there also are a number of mathematical skills that are crucial for climate change adaptation. These include thinking mathematically; posing and solving mathematical problems in a range of ways; modelling; reasoning; representing phenomena mathematically; manipulating mathematical symbols, formulas and phrases; and communicating mathematically (Kerry, 2010). In a study conducted in Canada involving municipal employees in a coastal community and farmers with the aim to understand human competencies for adaptation to climate change, Kerry et al (2012) identified the following competencies as crucial for adaptation: local knowledge, futures thinking, decision making, problem solving, optimism and openness to novelty. In a case study of climate change mitigation behaviour in families, Leger and Pruneau (2012) found that the following competencies are essential for changing behaviour and attitudes to climate change: collaboration, self-regulation, perseverance, self-efficacy and decision making. In another study, entitled ‘Seed of knowledge: Contributing to climate change solutions’, the United Nations Environmental Programme (UNEP) (2012) identified ecosystem management, ability to work in partnership with other people or groups, risk management, and exit strategy as key competencies for climate change adaptation.

2.3.2.2 Climate Change Pedagogy

Climate change is an environmental problem for which urgent sustained action is needed (IPCC, 2014; Brookings Institute, 2014). The processes, causes and impacts of climate change are still issues of debate among scientists and ordinary people. Climate change education can promote the development of problem-solving skills if appropriate pedagogies were applied. For individuals to respond effectively and efficiently to climate change they should not only understand the processes, causes and impacts of climate change; rather, they should be able to act on it. Hence climate change education seeks to develop the competencies people require to understand and respond to climate change. At the moment there is no specific pedagogy for the teaching the science of climate change in schools. However UNESCO (2009) recommended a problem-based participatory learner-centred pedagogy which requires that teachers understand the implications of climate change education and the need for it, and to have the competence and confidence to introduce it into their classroom teaching. This approach to instruction involves a shifting away from traditional behaviourist teacher-centred approach which focuses on the use of cues, shaping and practice to build a strong stimulus-response association to constructivist approach (Ertmer and Newby, 2013; Anyanwu, 2008; Bargh and Ferguson, 2000; Cooper, 1993).

2.3.2.2.1 Constructivist Teaching

Constructivism is one of the latest catchwords in education circles in recent years (Zhao, 2003). Constructivist learning started to gain influence in education following widespread criticism of behaviourism due to its emphasis on learning of facts and acquiring knowledge through the use of traditional skills and inability to promote the development of higher order cognitive skills (Ertmer and Newby, 2013; Anyanwu, 2008; Bargh and Ferguson, 2000; Cooper, 1993). Following the criticism, some scholars such as Jean Piaget and Lev Vygoysky began to theorise about how human beings construct new knowledge, and their theories have inspired the development of a number of models of classroom teaching. In some ways the theorisations share a common assumption: that teaching is more effective when driven by an understanding of how learning occurs; an assumption that has inspired an enormous body of work in education on constructivism. For the purpose of this thesis two dominant theories of constructivist learning are discussed: cognitive constructivist theory of learning and social constructivist theory of learning.

Piaget's genetic epistemology and Vygotsky's social learning theory have played an important role in defining the principles of constructivist learning and teaching. Piaget's genetic epistemology claims that humans should not be given information which they immediately comprehend and apply; instead, they must be allowed to construct their own knowledge through experience (1972, 1973). Vygotsky's social learning theory which claims that individuals build up mental frameworks through social and interpersonal interactions (Dennick, 2012; Taber, 2011; Pritchard and Woollard, 2010; Kukla, 2000; Vygotsky, 1978). Both theories claim that people construct knowledge through interaction with the environment (Gordon, 2009; Aydam, 2007; Zhao, 2003). Central to Piaget theory cognitive theory and Vygotsky social learning theory is the belief that the knowledge individuals construct by themselves is more enduring than the knowledge transmitted to them by someone else. Based on the principles of genetic epistemology theory and social learning theory, some guidelines for constructivist teaching have been provided.

Dennick (2012:619-623) provides twelve guidelines or tips for the implementation of constructivist teaching. These include:

- "Ascertain and activate prior knowledge,
- Build and existing knowledge and challenge misconceptions,
- Facilitate social construction of meanings using group work. Stress the context and the situation,
- Use active learning techniques, and
- Encourage learners to thinks about how they learn and give learners responsibility for their learning."

Other tips include ensure learners get the experience they need; reflection is helped by log-books, portfolios and feedbacks; build up mental models, practical skills and attitudes; allow learners to engage in hypothesis testing and action planning; respect learners and acknowledge who they are and where they are coming from; ensure physical, psychological and emotional needs are taken care of; and teaching and learning is a relationship (Dennick, 2012).

Brooks and Brooks (1993) also provide an explicit guideline for the implementation of constructivist teaching. They suggest that teachers should encourage and accept learners' autonomy and initiative; use raw data and primary sources along with manipulative, interactive and physical materials; and use cognitive terminology such as classify, analyse, predict and create when framing questions. Teachers should also allow learner responses to drive lessons, shift instructional strategies and alter content; inquire learners' understandings of concepts before sharing their own understandings of those concepts; encourage learners to engage in dialogue, both with the teacher and with one another; encourage learner inquiry by asking thoughtful, open-ended questions and encouraging learners to ask questions to each other; and seek an elaboration of the students' initial responses. According to Brooks and Brooks (1993) constructivist teachers engage learners in experiences that might engender contradictions to their initial hypotheses and then encourage discussion; allow wait time after posing questions; provide time for learners to construct relationships and create metaphors; and nurture learners' natural curiosity through the frequent use of the learning cycle model. For Konings, Brand-Gruwel and Van Merrienboer (2005), a constructivist learning environment should provide learners opportunity to build new knowledge on pre-existing knowledge, and the opportunity to recombine acquired skills, knowledge and attitudes effectively to solve problems in new situations. These abilities, Konings, Brand-Gruwel and Van Merrienboer (2005:648) stressed, can only be attained through self-directed and independent way of learning and thinking.

Common in the guidelines provided by (Dennick, 2012); Konings, Brand-Gruwel and Van Merrienboer (2005), and Brooks and Brooks (1993) is the fact that a constructivist learning environment enables learners to modify inaccurate mental models or simply conceptual change. The term 'conceptual change' is the terminology of cognitive science, but recently has become one of the central issues in education, and in particular in constructivist pedagogy. The most influential conceptual change models assume that each learner comes to school with misconceptions about natural phenomena. One of the issues in research on science education, of which climate change education is one is understanding how learners progressively shift from having misconceptions to having a correct understanding of a complex phenomenon. Cakir (2008:197) explains the nature of misconceptions and why they are resistant to change: Misconceptions are deeply seated and likely to remain after instruction in the students' cognitive structure, or even to resurface some weeks after learners have displayed some initial understanding immediately following instruction. Learners cling to their erroneous beliefs tenaciously and, because they spent considerable time and energy constructing their naive theories, they have an emotional and intellectual attachment to them.

The idea of conceptual change originates from the constructivist notion that all learning is a process of personal construction and that learners, given the right opportunity, will construct a scientifically orthodox conception of physical phenomena if they see that the scientific conception is superior to their pre-instruction conception (Cobern, 1995:2). In a climate change lesson the task that confronts the teacher is how to understand the components of an individual's conceptual ecology so that the right kind of experience can be provided. The incorporation of new experiences with their existing conceptual ecology will enable learners to see that scientific conceptions are superior to their own preconceived non-scientific beliefs.

Several instruction strategies to facilitate conceptual change have been advocated. These include the Science Activity Model (Linn, Lewis, Tsuchida and Songer, 2000), the Interactive Engagement Model (Biddulph, 1990), and the Learning Cycle Model (Glasson 1993; Lawson 1983). These instruction models are founded in constructivism. They recognise the role of prior knowledge in conceptual change. Jenkins (2000:605) suggest that instructions aimed at facilitating conceptual change must begin with finding out what learners know, then providing appropriate experiences that will confront their prior conceptions. This kind of instruction provokes cognitive conflict where learners are placed in a position in which the application of their own understanding to a problem could result in cognitive difficulties that the learners must then resolve. This means that, for conceptual change to occur, learners must first be discontented with their current ideas. It is the cognitive difficulties resulting from the application of their own ideas and the discontentment associated with it that motivates them to search for new information to modify their non-scientific ideas. Thus, instruction that inspires conceptual change should be problem-based and learner-centred to afford learners the opportunity to formulate their own ideas, search for new knowledge, analyse their initial conceptions, and transfer new knowledge in multiple contexts (Anyanwu, 2008). Some of the instructional models that facilitate conceptual change are discussed below.

2.3.2.2.2 Constructivist Instructional Design Models

Central to constructivist pedagogy is the idea of learning as meaning making and problem solving. This principle has guided some researchers to develop models of constructivist-based instruction, such as Problem-Based Learning, Inquiry-based Learning, Cooperative-Based Learning, and Cognitive Apprenticeship Learning. These models are described below.

a. Problem-Based Learning

Problem-based learning (PBL) is a constructivist pedagogical approach developed in September 1969 by Barrow and his colleagues at the McMaster University Medical School, Canada for educating medical students to become physicians (Cheong, 2008). The main intent of employing PBL is to overcome practical problems of learner boredom, learners’ inability to apply what they have learned in school in real life situation, and the lack of professional skills required to address challenges in society (Newman, 2005). According to Zoller and Pushkin (2007), problem solving denotes that there is a problem to be solved or a gap to be filled, which could be qualitative or quantitative. It could be intellectually and cognitively challenging conceptual questions that may require several cycles of interpretation, representation, planning, deciding, execution, evaluation and re-evaluation.

Many people think PBL is same as problem-solving learning (PSL) but that is not the case. In PSL, learners are given a lecture followed by a set of questions based on the information given during the lecture. Learners are expected to find solutions to these questions and bring them to the class for discussion. The focus is largely on finding the answers expected by the teacher and these answers are rooted in the information supplied to learners by the teachers during the lecture. On the other hand, PBL focuses on organizing curricula around problem scenarios and learners are not required to acquire a predetermined series of right answers. Instead they are expected to engage in the complex situation presented to them and decide what information they need to learn and what skills they need to gain in order to solve the problem (Cheong, 2008, Barron and Darling-Hammond, 2008). In addition, PBL has been found to improve learner achievement (Johnson, Smith, Smythe and Varon, 2008). According to Cheong (2008:49), PBL is a revolutionary and radical teaching approach as it is completely different from the traditional lecture-tutorial approach. There is a shift of power from the ‘expert teacher’ to the ‘student learner’. In the traditional teacher-centered approach, the teacher is knowledgeable in the subject matter and the focus of teaching is on the transmission of knowledge from the expert teacher to the novice student. In contrast, the PBL approach is a student-centered approach in which the focus is on student’s learning and what they do to achieve this. In such an environment, the role of the teacher is more of a facilitator than an instructor. This approach of instruction places is challenging on faculty as it takes time and expertise to develop suitable problems, to coach students, and to facilitate problem-solving sessions.

Savery and Duffy (1995:8-9) provides a more detailed account of the nature of PBL. In PBL, the learners begin the problem "cold", that is, they do not know what the problem will be until it is presented. They discuss the problem, generating hypotheses based on whatever experience or knowledge they have, identifying relevant facts in the case, and identifying learning issues. The learning issues are topics of any sort which are deemed of potential relevance to this problem and which the group feels they do not understand as well as they should. A session is not complete until each learner has an opportunity to verbally reflect on their current beliefs about the solutions, and assume responsibility for particular learning issues that were identified. Usually there are no pre-specified objectives presented to the students rather the learners generate the learning issues (objectives) based on their analysis of the problem. After the session, the learners engage in self-directed learning with no texts assigned to them rather they are totally responsible for gathering the information from the available resources, including resource persons. After self-directed learning, the learners meet again to evaluate the information that they have gathered – sorting out what was most useful and what was not so useful. It is at this stage they begin working on the problem with the new level of understanding they have gained. Here, the learners do not simply tell what they learned but use their new understanding in re-examining the problem. The assessment involves self and peer evaluation, with suggestions for improvement.

Macdonald and Savin-Baden (2004) provide a set of principles for assessment of learning outcomes in a PBL scenario. They recommend that assessment should ideally be based in a practice context in which learners will find themselves in the future - whether real or simulated. Teachers are also advised to assess what the professional does in their practice, which is largely process-based professional activity, underpinned by appropriate knowledge, skills and attitudes. Assessment should reflect the learner's development from a novice to an expert practitioner and so should be developmental throughout the programme of studies. Learners should begin to appreciate and experience the fact that in a professional capacity they will encounter clients, users, professional bodies, peers, competitors, statutory authorities, etc. who will, in effect, be 'assessing' them. Learners should be able to engage in self-assessment and reflection as the basis for future continuing professional development and self-directed learning. Finally, teachers must ensure that there is alignment between our objectives and the students' anticipated learning outcomes, the learning and teaching methods adopted, and the assessment of learning strategies, methods and criteria. Based on these principles one may conclude that PBL follows the same procedure as inquiry based learning. The only difference between inquiry-based and problem based learning is that in PBL learners are confronted with a real problem of global importance.

Climate change is an ecological problem facing all communities. Implementing Problem-Based Learning models during climate change lessons will help in climate change Exposing learners to understand they have a role to play helping learners to understand that climate change is real – it is affecting their locality in many different ways and to search for solutions to reduce the consequences of climate change in their local environments.

b. Inquiry-based Learning

Inquiry is a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories (NRC, 1996:214). Inquiry learning, originated by Jerome Bruner (1966), is an inductive approach to teaching and learning begin with a set of observations or data to interpret, or a complex real-world problem, and as the students study the data or problem they generate a need for facts, procedures and guiding principles (Prince and Felder, 2006). Inquiry-based learning is supported by the assumption that new ideas are discovered by exploring multiple perspectives on a given situation or phenomenon. Through exploration of perspectives the learners develop flexibility in thinking and reasoning skills. To facilitate the development of inquiry skills, learning experiences should be designed in ways that make learners willing and able to discover new ideas. The teacher must be aware of the importance of learning readiness and the way to organise and how learning experiences should be presented to make sense to the learners (Hmelo-Silver, Duncan and Chinn, 2007; Kirschner, Sweller and Clark, 2006).

Kalpana (2014) emphasises that inquiry based learning begins with the teacher presenting a puzzling question which requires the learners to formulate hypotheses to explain the event; collect the relevant data to test the hypotheses, and draw conclusions. These features suggest that effective inquiry is not just asking questions rather it is a complex process where learners formulate questions, investigate to find answers, build new understandings, meanings and knowledge, and then communicate their understandings to others. It is through these activities learners experience the processes of knowledge creation. Anyanwu (2008:69) describes inquiry as a critical search for new ideas with a view to illuminate some propositions. He emphasised that because knowledge is not static, learners must search for it if they wish to develop new ideas. Searching for meaning promotes meaningful engagement of the learner in the learning process. Through active engagement promotes discovery of new ideas. New ideas are essential elements for reconciling alternative conceptions.

Barron and Darling-Hammond (2008:1) described inquiry-based learning project-based meaningful learning. They outlined five key components of effective inquiry-based learning, as:

- “Central to the curriculum,
- Organized around driving questions that lead students to encounter central concepts or principles,
- Focused on a constructive investigation that involves inquiry and knowledge building,
- Student-driven (students are responsible for designing and managing their work), and
- Authentic - focusing on problems that occur in the real world and that people care about.”

The essential feature of a teaching system designed to emulate professional practice is that the crucial assessments should be performance-based, holistic, allowing plenty of scope for students to input their own decisions and solutions (Biggs, 2003: 237). Despite numerous benefits of inquiry-based learning, teachers complain that inquiry-based learning is too time consuming and the curriculum is overloaded (Abdelraheem and Asan, 2006).

Inquiry-based Learning will play an important role in developing learners’ ability to pose questions about climate change such as: What are the causes of climate change? What impacts does climate change have on society? What actions are required to mitigate the causes of climate change? What should local communities do to adapt to climate change impacts? Through search for answers to these questions, learners come to a better understanding of the science of climate change.

c. Cooperative Learning

The term Cooperative Learning according to Felder and Brent (2002) refers to learners working in teams on an assignment or project under conditions in which certain criteria are satisfied, including that the team members be held individually accountable for the complete content of the assignment or project. CL highlights that cooperative learning is not simply a synonym for leaners working in groups rather it highlights the importance teamwork to accomplish some set education goals. This learning approach has been called different names such as collaborative learning, collective learning, learning communities, peer teaching, peer learning and team learning. A team often consists of learners of different abilities, interests and needs. The team is rewarded on the basis of the success of the entire team. While CL makes it possible for learners to construct knowledge in a group, each learner is afforded the opportunity to achieve his or her learning goal if and only if the other group members achieve theirs (Kalpana, 2014).

Johnson, Johnson and Smith (1998) provide a number of elements of effective cooperative learning. These include:

- Positive interdependence. Team members are obliged to rely on one another to achieve the goal. If any team members fail to do their part, everyone suffers consequences.
- Individual accountability. All students in a group are held accountable for doing their share of the work and for mastery of all of the material to be learned.
- Face-to-face promotive interaction. Although some of the group work may be parcelled out and done individually, some must be done interactively, with group members providing one another with feedback, challenging reasoning and conclusions, and perhaps most importantly, teaching and encouraging one another.

- Appropriate use of collaborative skills. Students are encouraged and helped to develop and practice trust-building, leadership, decision-making, communication, and conflict management skills.
- Group processing. Team members set group goals, periodically assess what they are doing well as a team, and identify changes they will make to function more effectively in the future.

According to Dooly (2008:1) cooperative learning model involves learners teaching one another, learners teaching the teacher, and of course the teacher teaches the learners, too. Learners are responsible for one another's learning as well as their own and that reaching the goal implies that learners have helped each other to understand and learn. The overall goal of learning is accomplishment of a specific end product or goal through people working together in groups. For Bower and Richards (2006), working together allows learners to progress beyond what they would have been able to learn alone by sharing mental models and observing the thought processes of others. As opposed to direct instruction, cooperative learning promotes active participation in problem-solving processes by communicating about conceptual representations relating to the task at hand. The teaching model also allows tight-coupled interactions needed rapid and complex concept formation to occur. In a cooperative learning classroom, the teacher is a facilitator of learning.

Cooperative instruction models can be helpful in exposing learners to understanding how climate change affect their wellbeing and the wellbeing of other people in other parts of the world. This can be achieved by providing opportunities for learners to discuss climate change issues in small cooperative groups. This approach can help to exchange of ideas among the members of the group, so that those who hold misconceptions about climate change may be availed opportunity to modify their misconceptions.

d. Cognitive Apprenticeship Learning

Cognitive Apprenticeship learning is based on the assumption that that masters of a skill often do not take into consideration the inherent processes involved in carrying out complex skills when they are teaching novices. In order to make real differences in learners' skill, it is important for instruction designers to understand the nature of expert practice so that learning activities and environment are devised appropriate to learning that particular practice. Collins, Brown and Newman (1989) developed six teaching that can help learners develop cognitive and metacognitive skills for using, managing, and discovering knowledge. The methods include modeling, coaching, scaffolding, articulation, reflection, and exploration. Modeling, coaching and scaffolding are at the core of cognitive apprenticeship and facilitate cognitive and metacognitive development. Articulation and reflection are designed to help novices with awareness of problem-solving strategies and execution similar to that of an expert. Exploration guide the novice towards independence and the ability to solve and identify problems within the domain on their own. In this context, learning is facilitated when an expert (could be the teacher) stretches and supports the less experienced (the learner) through a processes of scaffolding and tutoring. The overall goal of cognitive apprenticeship is to make the thinking processes of a learning activity visible to the learner and the teachers through focusing on cognitive and metacognitive skills. In this way the learners are provided opportunity to think like experts (Kalpana, 2014; Fardanesh, 2006). According to Collins, Duguid, and Brown (1989) cognitive apprenticeship approach of learning is less effective when skills and concepts are taught independent of their real-world context and situation.

Cognitive Apprenticeship-based instruction can help learners to design and implement adaptation actions in their localities by following the principles of problem solving as done by scientists. The role of the teacher is to provide learners with authentic tasks similar to the problems facing the learners in their communities. Learners can be encouraged to conduct vulnerability analysis of their local communities using a set of guidelines.

2.3.2.2.3 Assessment and Learning

Assessment is an integral component of the constructivist approach to teaching. The main aim of constructivist teaching is to facilitate the construction and application of new knowledge. According to Snowman, McCowan and Biehler (2009:477), assessment involves collecting information about how much knowledge and skills an individual has learned, and making judgments about the adequacy of an individual's level of learning. Assessment serves different purposes in different contexts. For Palomba and Banta (1999:4), assessment is the systematic collection, review and use of information about educational programmes undertaken for the purpose of improving learning and development. For Dwyer (2008), assessment is the process by which we ascertain, through data collection, if learners have learned the skills, content and habits of mind that will make them successful; if learners are not learning, we decide on changes to the curriculum or teaching strategy to improve learning. The first meaning of assessment occurs at programme level – for managerial purposes, and the second meaning occurs at classroom level – for pedagogical purposes. Both managerial and pedagogical skills are relevant to improve learning outcomes. Assessment is probably the most important instrument teachers and education authorities can use to help learners learn and also to reveal deficiencies in schooling (Beets, 2012:15).

However, Beets and Louw (2011) take a more philosophical perspective on assessment. They argue that assessment, if well implemented, promotes social justice in the education setting. When poorly implemented, assessment can cause the degradation of social justice in the education system. Beets and Low (2011) maintain that degradation of social justice arising from ineffective and inefficient assessment marginalizes the learners, making it difficult for them to fulfil their potentials. In an era with visible impacts of climate change, assessments that deprive the learners the opportunity to develop their full potential may undermine effort to promote the development of the competencies that the learners need to respond to climate change. Assessment in a climate change lesson should not be about paper-pencil assessment that currently characterize the education system; good assessment should provide opportunity for learners to construct their own knowledge and also test the validity of the knowledge they have constructed by applying them in real life situations. In a climate-change lesson, well-constructed assessment can enable the teacher to identify learners' misconceptions and their strengths so that appropriate interventions can be applied. Assessment can also provide learners the opportunity to consolidate and apply the concepts and principles they have learned in the classroom.

2.3.2.2.4 Challenges of Constructivist Teaching

Constructivist teaching comes with many challenges to experience and novice teachers. According to Gordon (2009), one of the challenges of constructivist teaching is that many current constructivist discourses make very few references to the lessons that can be learned from the cases of excellent constructivist teachers. The few teachers who rely on constructivist teaching methods are not fully aware of the epistemological and ontological assumptions of constructivism. They may be skilled at facilitating active learning experiences for their learners or designing authentic assessments, but lack a clear understanding of why such experiences are so important and how they are different from other traditional learning models. Gordon (2009) argues that without a clear understanding of the philosophical assumptions of constructivism, teachers cannot be expected to link constructivist objectives for learning with appropriate types of instruction and assessment or to adapt constructivist principles to their particular classroom contexts.

Furthermore, constructivist teaching is complex and unpredictable, as a result, teachers who choose the constructivist path are expected to work harder, concentrate more and embrace larger pedagogical responsibilities than when practicing traditional approach of teaching (Gordon, 2009). Gordon (2009) further stresses that beginning teachers, particularly those struggling with issues of classroom management, familiarity with the curriculum, and adjusting to the culture of the school, often find it difficult to implement constructivist teaching models in their classrooms. Due the complexity of constructivist teaching, some teachers are reluctant to embrace constructivist pedagogy (Webb and Webb 2004). Despite the challenges, research shows that constructivist-based instruction is more effective than traditional instruction in promoting the development of higher-order thinking and problem-solving skills (Khalid and Azeem, 2012; Fessakis and Karakiza, 2011; Anyanwu, 2008; Baser, 2006; Eryilmaz, 2004).

2.3.3 The Place of Climate Change Education in the South African Geography Curriculum

Geography is taught as a sub-discipline of Social Sciences from Grades 4 to 9, and as a subject on its own in Grades 10 to 12. Social Sciences consist of History and Geography. Whereas History is the study of change and development over time, Geography is the study of human and physical environments and processes over space and time (DBE, 2011b). Though kept separate, History and Geography complement each other in terms of knowledge with the aim to provide opportunities for learners to look at their own worlds with fresh, critical eyes, and to become familiar with a world beyond the world they encounter in everyday life (DBE, 2011a). The content and scope of geography in basic education in South Africa varies with grades. An overview of geography content for the various phases and grades is provided in Table 2.

Table 2 shows that geography content taught at the various grades of basic education in South Africa includes human and physical geography and is relevant for developing knowledge about climate variability and change. Like the climate change content, the content of basic education geography traverses many disciplines, hence geography, like climate change, is multidisciplinary.

Table 2: Overview of Geography content per schooling grade (DBE, 2011a:19-20; DBE, 2011b:11-12)

Phases	Grades	Content
Intermediate	4	Places where people live; map skills; food and farming in South Africa; water in South Africa.
	5	Map skills with a focus on Africa; physical features in South Africa; weather, climate and vegetation of South Africa; minerals and mining in South Africa.
	6	Map skills with a focus on the world; trades with a focus on South Africa and the world; population, with a focus on South Africa and the world.
Senior	7	Map skills with a focus on local maps; earthquakes, volcanoes and floods; population growth and change, with a focus on the World; natural resources and conservation in South Africa.
	8	Maps and globes, focusing on global and local; climate regions with a focus on South Africa and the World; settlement with a focus on Africa/South Africa; transport and trade, with a focus on South Africa and the World.
	9	Map skills, with a focus on topographic and orthophoto; development issues with a focus on South Africa and the World; surface forces that shape the earth (physical geography); resource use and sustainability, with a focus on the World.
Further Education and Training (FET)	10	The composition and structure of the atmosphere; plate tectonics, folding, faulting, volcanoes and earthquakes; population: structure, growth and movement; water in the world: oceans, flooding, water management; geographical techniques: topographic maps, GIS.
	11	Global air circulation, Africa's weather and climate; rocks and landforms, slopes and mass movements; development: differences, issues and opportunities; resources and sustainability: soil, energy; geographical techniques: topographic maps, aerial photos, orthophoto maps, GIS.
	12	Climate and weather: cyclones, local climate; geomorphology: drainage systems and fluvial processes; rural and urban settlement; economic geography of South Africa; geographical techniques: topographic maps, GIS, synoptic weather maps.

The teaching of geography in South Africa focuses on four big ideas, namely place, spatial processes, spatial distribution patterns, and human and environmental interaction, which are central to geographical knowledge. It is from these four big ideas that geography content and topics are drawn. By exposing the learners to these four big ideas, geography nurtures knowledge, skills and values, by:

- “explaining and interpreting both physical and human processes;
- describing and explaining the dynamic interrelationship between the physical and human worlds;
- developing knowledge about where places are and the nature of a range of different places at different scales;
- practising essential transferable skills – literacy, numeracy, oracy and graphicacy;
- promoting the use of new technologies, such as Information Communication Technology (ICT) and Geographical Information Systems (GIS);
- developing a commitment towards sustainable development;
- creating awareness and sensitivity to inequality in the world; fostering empathy, tolerance and fairness; and,
- making and justifying informed decisions and judgments about social and environmental issues” (DBE, 2011a:8).

These aims of school geography are consistent with the aim of climate change education.

Besides the development of geographic knowledge, the study of geography nurtures geographical skills and attitudes and values culminating in the development of personal and social competences (DBE, 2011a). Specific skills developed through the study of geography are as follows:

- Using verbal, quantitative and symbolic data forms such as text, pictures, graphs, tables, diagrams and maps;
- Practising field observation and mapping, interviewing people, interpreting sourcing and working with statistics;
- Applying communication, thinking, practical and social skills;
- Practising the following specific skills:
    - ➢ Identifying questions and issues
    - ➢ Collecting and structuring information
    - ➢ Processing, interpreting and evaluating data
    - ➢ Making decisions and judgment
    - ➢ Deciding on a point of view

- Suggesting solutions to problems and
- Working cooperatively and independently.

In addition to nurturing geographical skills, geographical education nurtures attitudes and values such as “a concern for the sustainable and fair use of resources for the benefit of all; recognizing the significance of informed decision-making; and, the application of geographical knowledge and skills in learners’ personal lives”. Other attitudes and values nurtured through geographical education include “respect for the rights of all peoples; and, a sense of fairness, sustainability and equality (DBE, 2011b:9). These geographical attitudes and values are also consistent with the competencies that are nurtured through climate change education. These accounts indicate that all the content topics in the geography curriculum are relevant for the development of knowledge and understanding about climate change.

2.3.4 Operational Definition of Climate Change Pedagogical Literacy

Before defining climate change pedagogical literacy operationally, it is necessary that the various concepts related to climate change pedagogy are located and categorised. This categorisation will enable the researcher to locate the subdomains of climate change pedagogy and define their relevant content topics. Figure 6 contains a list of key concepts linked to climate change pedagogy that were identified through the review of literature.

Subdomain A

Climate change education, environmental education, policies, aim, objectives, knowledge, understanding, capability, climate change literacy, competencies, education for sustainable development, education and children, curriculum implementation, school, education reform, quality teaching, teacher, learner, learning outcomes, curriculum review and revision, integration

Subdomain B

Paradigm shift, pedagogy, constructivism, problem-based learning, problem solving, competencies, higher order cognitive skills, knowledge construction, inquiry, review of meaning, transfer of knowledge, misconceptions, conceptual change, cognitive conflict, analytical thinking, decision-making, teaching, prior experience, assessment

Figure 6: Concepts linked to Climate Change Pedagogy

Figure 6 provides some of the key concepts that are linked to climate change pedagogy. Concepts in Subdomain A are associated with educational aims and significance. These concepts are mainly concerned with policy of climate change education. Concepts in Subdomain B are associated with pedagogy – beliefs about the methods and approach for teaching climate change in schools. Using the key concepts, the researcher derives the two subdomains of climate change pedagogy, as illustrated in Figure 7.

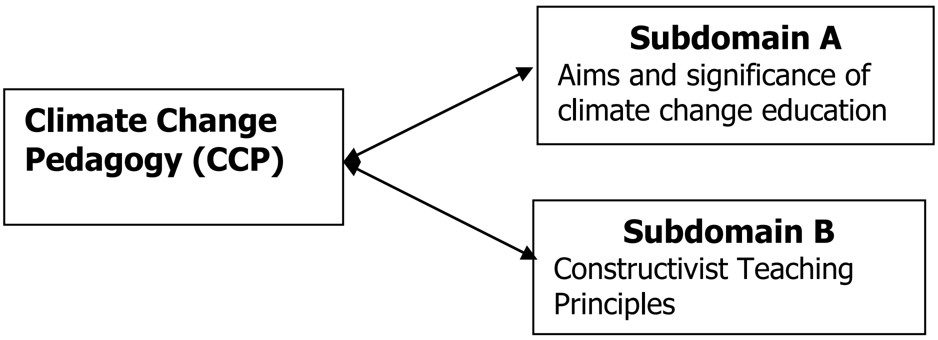

Figure 7: Subdomains of Climate Change Pedagogy

Figure 7 indicates that in the context of this study climate change pedagogy consists of two subdomains: aims and significance of climate change education and constructivist teaching principles. Based on UNESCO (2009a, 2009b), Pollard (2010), Stephen (2006), Leger and Pruneau (2012), Brooks and Brooks (1993), Beets and Louw (2011) the following content topics were selected for the assessment of climate change pedagogical literacy:

Aims and significance of Climate Change Education:

a) Climate change and children
b) Objectives of climate change education
c) Relationship between climate change and development
d) Competencies for adaptation to climate change
e) Assessing adaptation options

Constructivist teaching principles:

a) Cognitive conflict and learning
b) Process of knowledge construction
c) Transfer of knowledge
d) The process of conceptual change
e) Meaning and purpose of assessment

These two subdomains constitute Part C of the CCPLQ. The process of developing the CCPLQ is discussed in Chapter 3

The nature of climate change pedagogical literacy cannot be fully understood without reference to Figure 2 that shows the aspects of literacy and Figure 7 that shows the subdomains of climate change pedagogy. An attempt is made at this point to integrate these components of these two figures to derive a model of the elements of climate change pedagogical literacy, as shown in Figure 8.

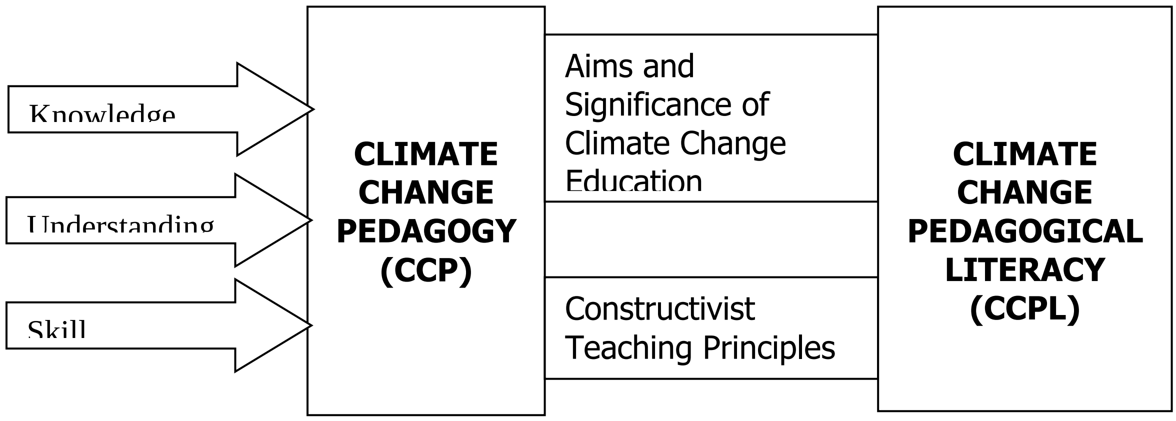

Figure 8: Elements of Climate Change Pedagogical Literacy

With reference to the elements shown in Figure 8, the researcher defines climate change pedagogical literacy (CCPL) as literacy in the aims/significance of climate change education and constructivist teaching principles and practice. An individual who is literate in climate change pedagogy demonstrates knowledge, understanding and skills for solving problems relating to the aims/significance of climate change education and constructivist teaching principles and practice. Having operationally defined climate change pedagogical literacy defined, the second main question that this study asked is: How literate are geography teachers in the Western Cape in climate change pedagogy? To investigate this second main question thoroughly, the following sub questions were investigated:

- How literate are geography teachers in the Western Cape in the aims/significance of climate change education?
- How literate are geography teachers in the Western Cape in constructivist teaching principles?

2.3.5 Relationship between Disciplinary Content Knowledge and Pedagogical Content Knowledge

Teaching is a complex activity which begins with a teacher's understanding of what is to be learned (content) and how it should be taught (Pedagogy) (Shulman (1986, 1987; Carpenter, Fennema, Peterson and Carey, 1988; Hill, Ball and Schilling, 2008; Koehler and Mishra, 2009). Content Knowledge (CK) also referred to as disciplinary content knowledge, common knowledge of content or core content knowledge encompasses an individual's understanding of subject matter concepts and how the concepts relate to form the larger body of knowledge (Hill and Ball, 2004; Ferrini-Mundy, Floden, McCrory, Burrill and Sandow, 2005). Pedagogical Knowledge (PK) on the other hand refers to those broad principles and strategies of classroom management and organization that appear to transcend subject matter (Shulman, 1987). Shulman (1987) argued that understanding what is to be learned and how it should be taught require teachers to have a broad knowledge base that includes other types of knowledge base such as;

- "Knowledge of learners and their characteristics;
- Knowledge of educational contexts, ranging from workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures;
- Knowledge of educational ends, purposes, and values, and their philosophical and historical grounds
- Curriculum knowledge, with particular grasp of the materials and programs that serve as "tools of the trade" for teachers; and
- Pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (Shulman, 1987:8).

Pedagogical Content Knowledge (PCK) encompasses understanding of how particular topics, principles, strategies and the like in specific subject areas are comprehended or typically misconstrued, are learned and likely to be forgotten. Such knowledge includes the categories with in which similar problem types or concepts can be classified, and the psychology of learning them. This definition suggests that PCK is different from Content Knowledge (CK) and Pedagogical Knowledge (PK), although it integrates elements of both. Koehler and Mishra (2009:64) describe PCK as knowledge of pedagogy that is applicable to the teaching of a specific content - how the teacher interprets the subject matter, finds multiple ways to represent it, and adapts and tailors the instructional materials to alternative conceptions and students prior knowledge. Carpenter, Fennema, Peterson and Carey (1988:386) explained that PCK involves knowledge of the conceptual and procedural knowledge that students bring to the learning of a topic, the misconceptions about the topics that they may have developed, and the stages of understanding they are likely to pass through in moving from a state of having little understanding of the topic to mastery of it. This clarification suggests that PCK involves knowledge of the nitty-gritties to facilitate learning in a specific content or subject-matter (Hill, Ball and Schilling, 2008; Carpenter et al, 1988).

2.3.6 Relationship between Climate Change Science Literacy and Climate Change Pedagogical Literacy

Drawing from the views of Shulman (1986, 1987), Carpenter, et al (1988), Hill and Ball (2004); Ferrini-Mundy et al (2005); Hill et al (2008); Koehler and Mishra (2009), the researcher's takes the perspective that teachers' climate change science literacy (subject matter knowledge) and their climate change pedagogical literacy (pedagogical content knowledge) are crucial in providing effective climate change instruction in schools. This view is also supported by CIRES (2015) which emphasises that effective Climate Change Education (CCE) requires teaching requires more than disciplinary content knowledge and an understanding of ways of knowing in the discipline. It requires teachers who understand the content of climate change science and are capable to effectively connect the science content with effective pedagogy. According to CIRES (2015), pedagogical issues related to effective climate change education include aligning interdisciplinary climate science with existing science curricula, anticipating student misconceptions, and being prepared to address public controversy around climate change in the classroom.

Climate change education, according to UNESCO (2009a:2), is not merely about increasing people's environmental awareness, but also helping them to understand and address the impact of global warming today, while at the same time encouraging a change in attitudes and behaviour required to act on climate change. Basically, the main aim of climate change education is to develop climate change science literacy. For CIRES (2012), if schools must promote climate change science literacy they must ensure that teachers themselves are literate in climate change science and literate in the pedagogy to communicate this science to the learners. Figure 9 illustrates the relationship between climate change science literacy and climate change pedagogical literacy.

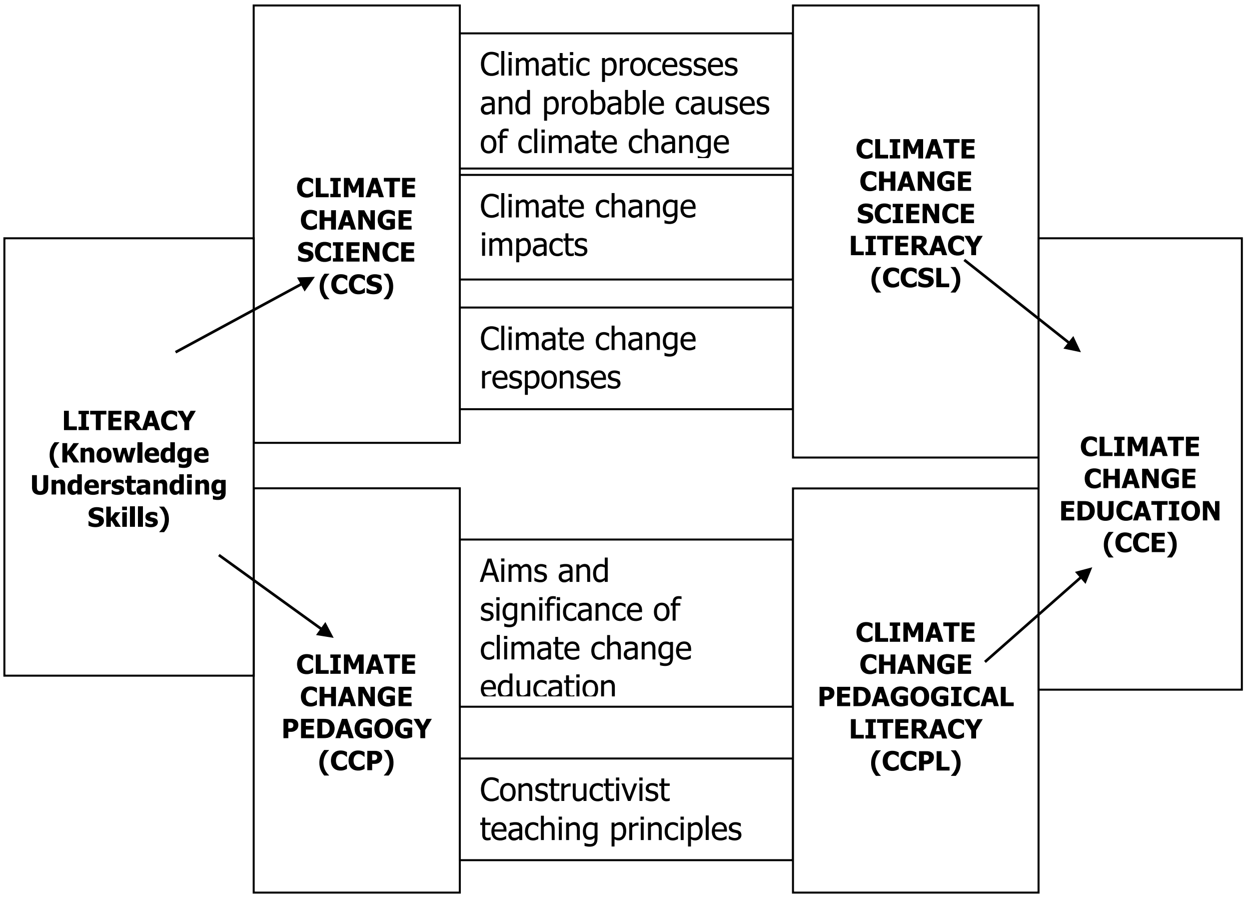

Figure 9: Relationship between Climate Change Science Literacy and Climate Change Pedagogical Literacy

In the light of Figure 9, the question that this study asks is:

- What is the nature of the relationship between teachers' climate change science literacy and teachers' climate change pedagogical literacy?

Feedback gathered by Lowther et al. (2012) from teachers who took the GCC course after they had completed the course showed that they still had difficulty incorporating STEM component into their instruction. The teachers encountered more difficulty with methods of teaching climate change than they did with content knowledge of climate change. This implies that teacher knowledge of climate change pedagogy does not improve with an improvement in their content knowledge of climate change. This finding is similar to that of Nwankwo and Onachukwu (2012), who found no significant difference in teacher level of awareness of the effects of climate change and classroom management strategies – teachers performed poorly on both. There also was no significant difference in the mean scores of male and female teachers in classroom management strategies, with both performing poorly.

Among the questions Liu et al. (2012) explored in their study of in-service teachers' attitudes and beliefs about climate change was how teachers' attitudes, beliefs, knowledge and classroom implementation of climate change were related. They found that the majority of teachers viewed teaching climate change to their students as important, but their opinions varied on the specific content topics to teach. They considered it critical that learners become aware that climate change is occurring and that they have a good understanding of its causes and effects. Nevertheless, cultural considerations and limitations in curriculum standards are barriers to implementing climate change education in schools. They also highlighted the lack of sufficient recent information and pedagogical content knowledge as key factors undermining their confidence in teaching climate change topics.

2.3.7 Methods of Assessing Climate Change Pedagogy Literacy

Climate Change Pedagogy Literacy (CCPL) in this study refers to knowledge and understanding of the applicable methods of teaching climate change content, which involves knowledge of the aim and significance of climate change education and knowledge of constructivist teaching principles as shown in Figure 8. Interest in research on teachers' awareness, understanding and knowledge of climate change is growing, but interest in research on the approaches and methods of teaching climate change in schools is still low, resulting in a paucity of research in this domain. Among the few studies on the pedagogy of climate change, most of them incorporated content knowledge. The main reason for reviewing some literature on the methods of assessing climate change pedagogy literacy is to gain an insight into the approach used by other researchers in the assessment of climate change pedagogy literacy.

Liu et al. (2012) investigated in-service teachers' attitudes and beliefs about climate change. Their study was based on the assumption that teachers' attitudes, beliefs and knowledge related to climate change have important effects on the climate literacy of future generations. One of the questions was: What is the nature of teachers' attitudes and beliefs about climate change and how do they develop over the course of climate change education professional development? The second question was about the relationship between teachers' attitudes, beliefs, knowledge, and classroom implementation of climate change. The participants were 19 middle and high school science teachers in Minnesota, USA. The study employed three methods of data collection: the Climate Change Attitudes Survey, the New Ecological Paradigm Scale, and concept maps and journal reflections.

The Climate Change Attitudes Survey contained 17 items that measure attitudes and beliefs about climate change and related policy making, in addition to open-ended and selected response items to assess teachers' general knowledge about climate change and classroom implementation of the climate change curriculum. The New Ecological Paradigm Scale to examine the degree to which people endorse an ecological worldview assessed teachers' beliefs about the relationship between humans and Earth. Concept mapping was employed to assess teachers' understanding of basic climate change concepts and their interconnections. In groups the teachers constructed concept maps reflecting what they learned each day. In addition they wrote journals each day based on their reflection on the driving questions related to content and developed action plans for how they would implement the content in their classroom. Data collected from the assessment was analysed with descriptive statistics. The results show that most of the teachers believed that climate change was occurring and was caused mainly by humans. Teachers who had more access to information about climate change also had fewer misconceptions about climate change. Their action plans revealed different depths of reflection on implementing climate change education, which means that some of them showed a shallow understanding of the aims and significance of climate change education and the methods of teaching concepts related to climate change.

In another study involving teachers in the United States, Lowther et al. (2012) assessed the efficacy of PBS TeacherLine's global climate change (GCC) course for middle school teachers in enhancing teachers' content knowledge of climate change, facilitating teacher's integration of NASA data models and other NASA resources into classroom instruction, and increasing teachers' use of interdisciplinary approaches and effective STEM (science, technology, engineering and mathematics) instruction strategies to teach climate change. The study employed quasi-experimental mixed methods design involving both quantitative and qualitative data. The sample consisted of 165 STEM (science, technology, engineering and mathematics) teachers of Grades 5 to 8, with the majority being women who had 4 to 15 years of teaching experience and most of them taught seventh or eighth grades. The participants were divided into two groups with 71 in the treatment group and 94 in the comparison group. The treatment group took the GCC course for one term in different locations in the United States. The comparison group took another PBS TeacherLine course in science, technology or mathematics for a term. As an incentive, all teachers who participated in the study got some financial rewards. The collected data included assessment and survey data, independent classroom observations, and structured interviews.

The assessment and survey data was collected from both groups on their content knowledge of global climate change and their integration of STEM teaching strategies and NASA resources into classroom instruction. Posttest data was collected online from the treatment group to ascertain their perceptions of the GCC course, including open-ended comments on the impacts of the course and the use of NASA resources on the teacher's instruction. The Global Climate Change Classroom Observation (GCC-CO) assessed teachers' global climate change instruction during the GCC-STEM classroom activity implemented by the teachers as part of the course project. Telephone interviews were conducted with randomly selected teachers who participated in the observations with the aim to corroborate information from the observation and surveys and to provide follow-up information. The collected data was analysed with quantitative and qualitative techniques. The results showed that teachers who took part in the GCC course demonstrated a significantly higher level of GCC content knowledge after completing the course than similar group who took another PBS course. In addition, teachers who took the GCC course perceived that the course strengthened their knowledge of the science of global climate change.

However, there was no significant difference between teachers who took the GCC course and teachers who took the other course – both groups showed a statistically significant increase in the use of STEM strategies during the course.

A survey of the work of other researchers, as done in this section, showed that climate change pedagogy literacy of teachers can be assessed with the qualitative method or the quantitative method, or both. The choice of research design also varied: some employed the non-experimental research design and others employed the experimental research designs, depending on the purpose of the study. The approach employed by the researcher in assessment of climate change science literacy and climate change pedagogy literacy of geography teachers in the Western Cape is discussed in Chapter 3.

2.4 SUMMARY OF THE CHAPTER

The two main constructs – climate change science literacy and climate change pedagogical literacy – are conceptual constructs, and as such they have latent meanings. Through extensive study of pertinent literature on literacy, science and climate change pedagogy, the elements and characteristics of climate change science literacy and climate change pedagogical literacy have been unveiled.

In this study, climate change science consists of three domains: climatic processes and probable causes of climate change, climate change impacts and climate change solutions. Climate change pedagogy, on the other hand, encompasses two domains: aim and significance of climate change education, and constructivist teaching principles. From a contemporary perspective, there are three dimensions of literacy - knowledge, understanding and skills/capabilities. For the purpose of this study, climate change science literacy encompasses literacy in climatic processes and probable causes of climate change, literacy in climate change impacts and literacy in climate change responses. Conversely, climate change pedagogical literacy encompasses the aim and significance of climate change education, and literacy of constructivist teaching principles. It requires teachers who are literate in climate change science (Content Knowledge) and literate in climate change Pedagogy (Pedagogical Content Knowledge) to promote climate change education in schools.

Previous research on the measurement of teacher knowledge of climate change and methods of teaching climate change in schools adopted mainly the positivist quantitative approach. This study takes the same approach. The methodology and procedure to determine the extent to which geography teachers in the Western Cape are literate in both climate change science and climate change pedagogy are discussed in the next chapters.

CHAPTER 3

METHODOLOGY AND PROCEDURE OF THE STUDY

This chapter presents the methodology and methods of this survey. Le Grange (2000:192) clarifies the difference between research methodology and research methods. Research methodology encompasses the philosophical positioning, theory of knowledge and interpretative framework that guides a particular research process. This is in contrast to the research method, which is the set of tools and techniques used for gathering evidence as part of a systematic inquiry within a given discipline. This chapter is divided into two parts. The first part focuses on the methodology of the study and the second part focuses on the procedure, which encompasses the instrumentation/instruments and techniques for the collection and analysis of the data.

3.1 THE METHODOLOGICAL CHOICE

3.1.1 Description of the Variables

A variable refers to a characteristic or attribute of an individual or an organisation that can be measured or observed and varies between the people or organisations being studied. It will typically vary in two or more categories or on a continuum of scores, and can be measured (Creswell, 2009:235) or divided into logical groupings of attributes (Babbie and Mouton, 2011:648). A variable can also be referred to as an empirical property that is observed to change by taking more than one value or being of more than one kind (Bless, Higson-Smith and Kagee, 2011:185).

Referring back to Chapter 1 Sections 1.6 and 1.7, this study seeks to answer research questions and to test a set of hypotheses. In terms of the research questions, the two main questions are: How literate are geography teachers about climate change science? How literate are geography teachers about climate change pedagogy? Figure 9 presented in Chapter 2 highlights climate change science literacy and climate change pedagogy literacy as the two main variables of this study. These variables are dependent because observations about them were analysed statistically in relation to what the teachers know, understand and could do about climate change science and climate change pedagogy

The area where the study was conducted is the Western Cape, which consists of eight education districts: Metropole Central, Metropole South, Metropole North, Metropole East, West Coast, Cape Winelands, Overberg, and Eden-Karoo. The 2011 Census Reports suggests that the Western Cape is the fourth largest province in South Africa, with an area of 129 462 km^2, which represents 10.6% of South Africa's 1 220 813 km^2 land area. The larger provinces are the Northern Cape (372 889 km^2), Eastern Cape (168,966 km^2) and Free State (129 825 km^2). The smallest among the provinces in terms of land area is Gauteng, with 18 174 km^2. In terms of population, the Western Cape had about 5,8 million people in 2011 out of a national population of about 51 million (Statistics South Africa, 2012).

Educationally, the Western Cape, North-west, Free State and Gauteng are the high-achieving provinces, whereas KwaZulu-Natal and the Northern Cape are medium-achieving provinces. Mpumalanga, Limpopo and the Eastern Cape are low-achieving provinces. This categorisation is based on reports on the National Senior Certificate district performance since 2009 (Department of Basic Education, 2013, 2012, 2011b, 2010, 2009). Taking into consideration the population of the Western Cape, any conclusions drawn on geography teachers in the province can be assumed to represent about 11% of the situation in South Africa as a whole, in addition to the situation in the other educationally high-achieving provinces in South Africa.

Politically, the Western Cape consists of eight districts. Districts such as Metropole Central, Metropole South, Metropole North and Metropole East are predominantly urban, whereas the West Coast, Cape Winelands, Overberg and Eden-Karoo are predominantly rural. The terms 'urban' and 'rural' are difficult to define. According to Du Plessis, Beshiri, Bollman and Clemenson (2002:6), the difficulty in defining them arises from the decision about the sense in which they are applied: as a geographical concept they are seen as a location with boundaries on a map or as a territorial unit. However, as a social representation, they can be interpreted as a community of interest, a culture and a way of life. An urban area is a geographical area within the jurisdiction of a municipality or town committee with a minimum of about 2 000 people, although the number varies globally between 2 000 and 50 000. A significant majority of the population in urban areas is not primarily engaged in agriculture (UNESCO, 2012).

In the South African context, an urban area refers to a place with some form of local authority. A rural area, on the other hand, is a geographic area that is located outside cities and towns. These are characterised by open areas with low population density and small settlements of fewer than 2 000, with a significant majority of people engaged in agriculture. Some rural areas have paved streets, electric lighting and sewerage as in urban areas, but the main economic activity is agriculture. A semi-urban area is an area between consolidated urban and rural regions. It includes areas that either are situated geographically in between city and countryside, or differ from urban areas and the countryside (Meeus, Leuven and Gulinck, 2008; United Nations, 2005; United States, 2000).

The districts also vary in terms of the number of geography teachers. Districts such as Metropole Central, Metropole South, Metropole North, Metropole East and the Cape Winelands have over fifty geography teachers each, and others, such as West Coast, Overberg and Eden-Karoo have fewer. This study assumes the ecological characteristics of the district could have an influence on teacher literacy in climate change science and climate change pedagogy (Bronfenbrenner, 1993). As Bronfenbrenner (1993:39) explains, within a given ecological setting, particularly at the micro-level, there are proximal processes that produce and sustain development, but their power to do so depends on the content and structure of the system.

Besides variations in the number of geography teachers by district, the teachers also vary in some personal characteristics. In this study, variables such as gender, age teaching experience and experience in teaching lessons on climate change occur in two main categories, for example gender (Male and Female), age (< 40 and > 40), teaching experience (< 10 and > 10), and taught lessons on climate change in the last year (Yes or No). Other variables, such as location of school, qualification, specialisation and grade mostly taught occur in more than two categories: school location (urban, rural, and semi-urban), qualification (Master's, Honours, Bachelors, Diploma, and Certificate), specialisation (Geo/Education, Geo only, Geo and another subject, others), and grade mostly taught (10, 11 or 12). These are categorical independent variables (IV). The study seeks to determine whether there are differences in the distributions of scores of the categories with reference to climate change science (DV) and climate change pedagogy (DV). The influence of the IVs and the DVs is illustrated in Figure 10.

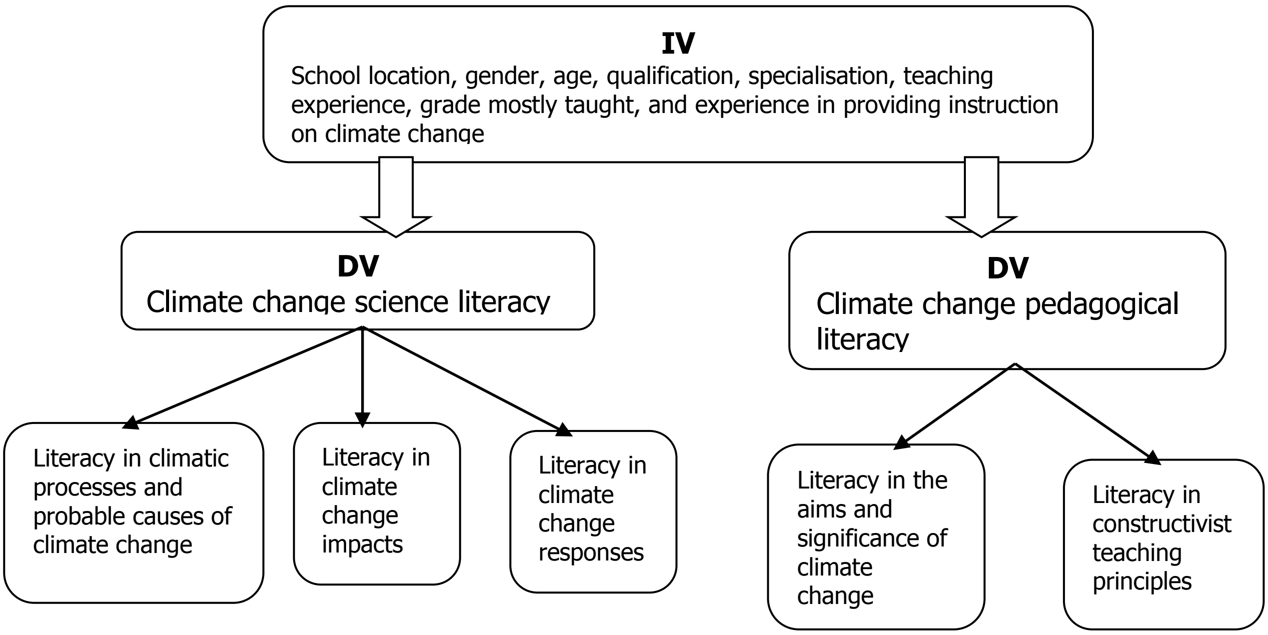

Figure 10: Main variables of the study

The operational definitions of climate change science literacy and climate change pedagogical literacy provided in Chapter 2 suggest that climate change science literacy can be measured in relation to literacy regarding climatic processes and probable causes of climate change, literacy regarding climate change impacts, and literacy regarding climate change solutions. Similarly, climate change pedagogical literacy can be measured in terms of literacy in the aims/significance of climate change education and literacy in constructivist teaching principles. The values of these elements are expected to vary in quantity along a measurement scale. Hence, these variables are referred to as continuous variables and their values were used in answering the research questions.

3.1.2 The Unit of Analysis

In research the unit of analysis refers to the persons, objects or events from which data will be collected and about which conclusion may be drawn (Bless et al., 2011:185). This study's unit of analysis is FET Geography teachers in the Western Cape. This means that the conclusions pertaining to FET Geography teachers' literacy in climate change science and literacy in climate change pedagogy are based on data collected from samples from the Western Cape, which characterises this research as nomothetic. Grice, Jackson and McDaniel (2006) describe nomothetic research as research in which quantitative variables involve generalising empirically verified knowledge to a group of individuals or populations. This is in contrast with idiographic research, in which the focus is on the uniqueness of individual participants or objects.

3.1.3 The Research Paradigm

A paradigm refers to a pattern or model of how something is structured. Often, concepts or objects are represented in two ways – the parts and their interrelationships, and how the parts function – behaviour within a specific context or time dimension (Huitt, 2011:1). This definition is similar to Kuhn's (1962:10) definition of paradigms as rules and standards for scientific practice. These two definitions suggest that a paradigm is about concepts and the actions that are taken to ensure that the choices that are made in the explanation of the concept are in conformity with scientific principles. Research, being a scientific human endeavour, is conducted with a set of principles or rules that guide how the researcher orients his thoughts, choices and action. Kafle (2011:193) describes a research paradigm as the metaphysics of research, which is constituted of ontology, epistemology and axiology. These philosophical considerations determine how a researcher undertakes his or her activities. Consequently, the philosophical considerations for this study focus on these three paradigms: ontology, epistemology and axiology.

3.1.3.1 Ontological Considerations

Ontology is the study of claims and assumptions that are made about the nature of social reality. It is concerned with claims about what exists, what it looks like, what unit makes it up, and how these units interact with each other (Mack, 2010:5). Clarifying a researcher's ontological position in research is important, because human existence has meaning in communication between and among individuals or groups. But, owing to the diversity of contexts and needs, people sometimes give different meanings to or make different claims about the same object or event. As a result, there is a lack of shared understanding of reality (Uschold and Gruninger, 1996:2). These views suggest that, unless a claim is based on a set of beliefs that is scientifically justified, any conclusions emanating from it could be defenceless.

Bahari (2010:23-24) provides two main ontological beliefs about reality: subjectivism and objectivism. Subjectivism is the belief that social phenomena are created from the perceptions and actions of those social actors concerned with their existence. This can be considered as a continual process. Conversely, objectivism is an ontological belief based on the assumptions that social phenomena and the categories that we use in everyday discussions have an existence that is independent or separate from actors. In this study, the meaning that the researcher gives to climate change science literacy and climate change pedagogical literacy and their sub-variables exists independently of the researcher and the research participants.

3.1.3.2 Epistemological Considerations

Epistemology is concerned with how we generate and acquire scientific knowledge (Hussein, 2009:5). Considering that this research is concerned with creating or expanding new knowledge about the climate change science literacy and climate change pedagogical literacy of geography teachers, it is crucial to determine at the onset the epistemological position that the researcher is taking to produce this new knowledge. Bryman (2009:27) suggests two main epistemological positions in research: positivism and interpretivism. Positivism is an epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond. This is in contrast to interpretivism, which is an epistemological position that requires the social scientist to grasp the subjective meaning of social action (Bryman, 2009:27). This research is oriented towards positivism or the scientific method because it is the researcher's intention to produce new knowledge about climate change science literacy and climate change pedagogical literacy based on the application of natural sciences methods. Consequently, this study is situated within the positivist tradition.

Positivism assumes quantitatively measured dependent facts about a single reality, as such data and its analysis should be value free and data does not need to change because it is being observed. It purports that the purpose of science is to stick to what we can observe and measure (Krauss, 2005:760). The purpose of research oriented towards positivism is to prove or disprove a set of hypotheses about reality (Mack, 2010:6). Although the present study investigates the influence of the IVs on the DVs, as shown in Figure 10 earlier in this chapter, its main focus is to statistically determine the level of literacy in climate change science and literacy in climate change pedagogy of the participants.

Generating statistical measures necessitates measurement by means of a standardised instrument. Measurement is the assignment of numbers to phenomena or objects according to rules that reflect or correspond to properties of the phenomenon or object (Bohrnstedt, 2010:348). An instrument is standardised when it measures consistently across occasions, across alternate forms of the same instrument, or within itself (Mushquash and Bova, 2007:55). Owing to a lack of standardised measurement instruments for the assessment of climate change science literacy and climate change pedagogical literacy in relation to their identified sub-variables in this study, a criterion-referenced multiple-choice test, designed by the researcher, was used instead.

3.1.3.3 Axiological Considerations

Axiology is a branch of philosophy concerned with responsible allegiance in which researchers are expected to demonstrate that the research project embodies the highest ontological principles, seek (or develop) an axiologically compatible knowledge-producing system to assist in realising the project, and abandon the project if it no longer serves the highest axiological principles (Hill, 1984:67-68). As Kafle (2011) argues, axiology is concerned with issues of value, which include ethics, pragmatics and aesthetics. Values provide the standard for the evaluation of epistemological and ontological claims. In reference to the research literature, axiology also refers to the involvement of the researcher's values and opinion in the process of knowledge generation (Kafle, 2011:194). It could be derived from these views that axiology is concerned with applying the right conduct in a research project. When axiological principles are applied correctly, the validity of the conclusions of a study is enhanced.

Bearing in mind that the data collection instrument for this study is criterion-referenced, axiology requires that the necessary steps must be taken to ensure that the instrument is reliable and valid before employing it for data collection. According to Drost (2011), reliability refers to the extent to which measurements are repeatable – when different persons perform the measurements, on different occasions, under different conditions, with supposedly alternative instruments that measure the same thing. Drost (2011:109) provides a list of measures to test instrument reliability: test-retest reliability, alternative forms, split-half approach, inter-rater reliability and internal consistency. On the basis that the measurement instrument is a criterion-reference multiple-choice type, the reliability of the instrument was determined with the split-half method and the internal consistency method. In the split-half method, the researcher derives two different parts from a number of items available to measure a behaviour such that half of the items are combined to form one new measure and the other half are combined to form the second new measure. In this way the researcher produces two tests and two new measures testing the same behaviour. On the other hand, internal consistency estimates consistency within the instrument. It focuses on the extent to which a set of items measures a particular variable within the test. For a test to be internally consistent, estimates of reliability are based on the average inter-correlations among all the single items within a test (Drost, 2011:111).

Validity, on the other hand, refers to how well an empirical indicator and the conceptual definition of the construct that the indicator is supposed to measure 'fit' together (Neuman, 2011:211). For Bohrnstedt (2010:372), an instrument is valid to the degree that it adequately measures the construct under investigation. Oluwatayo (2012:391) stresses that there is a shift from the historical emphasis on the degree to which a test or measuring instrument actually measures what it purports to measure, to the interpretation and measuring of the scores derived from the instruments. To fulfil the validity requirements of this study, the researcher thought the following: How well are the constructs transformed into a functioning and operating reality? Do the variables fully represent the constructs? Are the items in the instrument relevant, reasonable, unambiguous and clear? These three considerations centre on fitness, adequacy and relevance, which are concerned with construct validity, content validity and face validity respectively.

To guarantee that the instrument is reliable and valid before employing it for data collection, it was important to subject it to piloting. Van Teijlingen and Hundley (2001) suggest two models of piloting: conducting mini versions of a full-scale study (feasibility studies), and testing a research instrument, such as a questionnaire or interview schedule before employing it for data collection (pre-testing). This study identified with the latter, implying that piloting in this study was not about a feasibility study; rather, it was about ensuring the instrument was fit and adequate before employing it for data collection.

3.1.4 Nature of the Research

Research is a systematic, controlled, empirical and critical investigation of natural and social phenomena, guided by theory and hypotheses about the presumed relations between such phenomena (Imenda, 2014:186). As a human activity, every research has a purpose for which it is designed and conducted. According to Durrheim (2002:34), there are three main techniques for demarcating a research study in relation to its purpose. These include exploratory, descriptive and explanatory research; applied and basic research; and qualitative and quantitative research. By the nature of its purpose, as indicated in section 1.5, this study is basic, descriptive, explanatory and quantitative research. Details of these four types of research are provided below.

3.1.4.1 Basic Research

Basic research, also known as fundamental or pure research, is motivated by a researcher’s curiosity or interest in illuminating a problem in research. Its main rationale is to develop knowledge, not to create or invent something. This is in contrast to applied research, in which the motivation is contributing to the solution of specific practical problems. The difference between basic research and applied research can be likened to the difference between science and technology (Roll-Hansen, 2009:2). This study is basic research in the sense that it seeks to develop knowledge about the status of geography teachers in the Western Cape in relation to their literacy in climate change science and literacy in climate change pedagogy.

3.1.4.2 Descriptive Research

Descriptive research refers to research studies that have as their main objective the accurate portrayal of the characteristics of persons, situations or groups (Polit and Hungler, 2004:716). Studies that employ a descriptive design aim to provide an accurate portrayal of the characteristics of persons, situations or groups (Polit and Hungler 2004:716). They are concerned with describing a population with respect to important variables and determining the proportion of individuals who portray some characteristics of interest. They are also useful in making specific predictions and in determining relationships between variables. Descriptions often provide factual accounts about a phenomenon, yet some factors that influence that phenomenon reside outside the particular context that gives meaning to those factors. Descriptive studies often disregard those factors. As a result, descriptive studies often draw erroneous conclusions (Grimes and Schulz, 2002:145). This is in contrast to exploratory research, in which the intent is to gain new insights, discover new ideas, and increase knowledge of the phenomenon (Burns and Grove, 2001:374).

The main intent of this study was to assess geography teacher's climate change science literacy and climate change pedagogical literacy, as indicated in the purpose statement in section 1.5. Primarily, the objective was to describe the demographics of the respondents and determine their level of literacy regarding climate change science and climate change pedagogy, which fulfils the descriptive component of the purpose of this study.

3.1.4.3 Explanatory Research

In this study, an attempt was made to describe a sample of geography teachers in the Western Cape in relation to the three measurement variables of climate change science literacy and two measurement variables of climate change pedagogical literacy, without disregarding the influence of mediating variables, including the area where their schools are located, gender, age, qualification, specialisation, teaching experience, grade mostly taught and experience in providing instruction on climate change. Typical of the natural sciences, as mentioned earlier, the purpose of research is not merely to describe how things are, but to say why things are the way they are. Unlike the descriptive component of this study, which aimed to describe the extent to which geography teachers are literate in climate change science and literate in climate change pedagogy, the explanatory component sought explanations for why some geography teachers were more or less literate than others. In explanatory research, the researcher enters the research situation with an a priori theory (assumptions), and the purpose of the data collection is to confirm or disconfirm that theory (Eastwood, Jalaludin and Kemp, 2014:3).

The main aim of explanatory research is to identify and test any causal links between the variables relating to the research problem using statistical models (Shmueli, 2010:289). In this present study, a number of mediating variables that could influence the literacy of geography teachers in relation to climate change science and climate change pedagogy were identified, and it is proper that the magnitude of the influence of these mediating variables was verified. Also, it was assumed that a relationship exists between teacher climate change science literacy and teacher climate change pedagogy. It is also important to verify and explain the nature of the relationship.

The fact that the variables of this study are quantitative (continuous variables and categorical variables) necessitates inquiry using the quantitative approach, which is a tradition of the natural sciences. Ossenbrink (2013) makes a clear distinction between the approach of the natural sciences and the approach of the social sciences. In natural sciences the focus is on objects or processes that are of a physical nature and that are studied through observation and experimentation. The goal of experimentation and observation in the natural sciences is to understand phenomena in the physical world through testing and prediction, using mathematics and logic. Often, the object of analysis in natural sciences is nature. Unlike the natural sciences, which explore complex systems in an attempt to understand the behaviour of the individual elements within the systems, the social sciences explore the individual elements in an effort to understand the behaviour of the entire system. Social sciences explore phenomena using the qualitative method or quantitative method or both (mixed) methods, and in most cases the object of analysis is social actors (people). Social sciences generate fallible and infallible theories by identifying patterns of collective action emerging from the observation of individuals through their independent actions.

3.1.4.4 Quantitative Research

The quantitative approach is situated within the positivist method, which is also referred to as the scientific method. Although the scientific method is an overriding feature of the natural sciences, Livesey (2006:1) emphasises that some complex social issues/problems can be adequately explored and understood using the scientific method. Quantitative researchers believe that genuine knowledge is derived from sense experience – through observation and experiment. They claim that genuine knowledge of reality can be gained by seeking causal determination, prediction, and generalisation of findings (Golafshani, 2003:600; Babbie and Mouton, 2011:53). According to Bryman (2008:175-176), the main preoccupations of quantitative research include measurement, causality, generalisability and predictability. These preoccupations reflect epistemologically grounded beliefs about what constitutes acceptable knowledge. These preoccupations are considered during sample selection, instrument development, data collection and data analysis.

3.1.5 The Research Model

Lavrakas (2008) categorises quantitative research into four designs based on their strength to exercise control over the variables: true experimental design, quasi-experimental design, pre-experimental design, and non-experimental design. This research is a non-experimental research project in the sense that its intent is to answer a set of research questions about the current state of affairs, identify factors and relationships among them and create a quantitative description of phenomena. Lavrakas (2008) also provides four main variants of non-experimental research: non-experimental survey research, correlational research, causal-comparative research, and meta-analysis research. The fact that this study involved collecting data from a representative sample of FET phase geography teachers in the Western Cape using criterion-referenced close-ended questions makes it a survey. According to Kasunic (2005:3), a survey is a “data-gathering and analysis approach in which respondents answer questions or respond to statements that were developed in advance.” This definition suggests that a survey is a research strategy in which participants are asked a set of pre-planned questions on a particular issue and then analysing the answers that they provided.

Like every human endeavour, a research project has a purpose. For the research to achieve its purpose, the plan must follow a set of principles or guidelines. Gavin (2008:151) provides a list of principles that guides a survey. These include:

a) "Surveys gather information from a proportion of a population of interest and the size of the sample depends on the purpose of the study;
b) The sample is not selected haphazardly or only from people who volunteer to participate. It is scientifically chosen so that each person in the population will have a measurable chance of selection;
c) Information is collected by means of standardized procedures so that every individual is asked the same questions. The survey intent is not to describe the particular individuals who are part of the sample, but to obtain a composite profile of the population; and,
d) Individual respondents should never be identified in reporting survey findings. All survey results should be presented in completely anonymous summaries, such as statistical tables or charts."

These principles were applied in the entire design of the research process for this study. Items a) and b) are concerned with sample and sample selection, item c) is concerned with instrumentation and data collection, and item d) is concerned with ethical issues.

One of the important considerations in a research project is how data will be collected from the research participants. This consideration is important because the way and manner in which data is collected in a study has a lot to do with the validity of the results. Survey research employs two main strategies of collecting survey data from research participants, namely a longitudinal strategy and a cross-sectional strategy (Bless et al., 2011; Shuttleworth, 2009; Trochim, 2006). A longitudinal strategy involves repeated measurement of the same participant over a time long enough to encompass a detectable change in their development status. On the other hand, a cross-sectional strategy is suitable when the researcher is to collect data from a large number of research participants at the same time. The difference between a cross-sectional strategy and a longitudinal strategy lies in the length of time of observation of the subjects. This study adopted a cross-sectional strategy of data collection in terms of which the data collected reflect the participants' current level of literacy in climate change science and climate change pedagogy at the time of the study.

3.2 PROCEDURE OF THE STUDY

3.2.1 Sample Selection

Selecting the sample for this study was a mammoth task, since there was no complete and official list of geography teachers by name in each district. The researcher made several calls to the provincial education department requesting a list, but the reply was that such a list did not exist. The provincial office advised the researcher to contact the district offices, but that could not help either. However, the researcher was able to access the official website of the Western Cape Department of Education and eventually got a list of the high schools in the Western Cape as in Appendix 1 (Western Cape Department of Education, 2014).

Consequently, there was no sampling frame from which the researcher could select the research participants. A sampling frame of geography teachers in the Western Cape should contain all geography teachers with numerical identifiers, including their contact details. Besides the issue of the absence of a sampling frame, ethical guidelines convey to the participants the choice to decide whether to participate in the assessment or not. This also made it difficult to decide in advance on a specific sample size for the survey.

With the absence of a sampling frame, the researcher decided that the best option would be to watch out for any gathering of geography teachers at the provincial or district level. An opportunity came during the marking of the National School Certificate Examination in December. To gain access to geography teachers at the venue, the researcher applied for the job of script checker for geography in one of the marking venues at the Cape Peninsula University of Technology. Although the researcher was admitted to do the job and the teachers were enthusiastic about the study, it was not possible to administer the questionnaire considering the pressure and condition they were working under. They called in at 7:00 and knocked off at 21:00 and sometimes later. The venue where the researcher was stationed had about one hundred geography teachers. Everyone was working very hard to complete the marking and get ready to travel for the Christmas holidays. Apart from realising that the work conditions at the marking centre were not proper to ask teachers to complete the questionnaire, the centre supervisor also suggested that teachers might complete the questionnaire when they returned to their schools the next year. So the effort to administer the questionnaire at the marking venue met with a dead end.

At this point, the researcher started getting worried that the study was getting to a dead end – a matter that was discussed with his supervisor to convey frustration, but also exploring how the problem may be solved. The plan then was to ask District Subject Advisors for Geography if the questionnaire could be completed by teachers after their specific workshops. The geography subject advisors in all education districts in the Western Cape were approached. The response was positive and the subject advisors pledged assistance to ensure the questionnaire was administered. Based on the estimates of the subject advisors, there were about 408 geography teachers in the province at the time of the study. Based on this number, the researcher decided to use 10 geography teachers for piloting, while targeting at least 150 geography teachers for the survey. Hence, the sample was selected using a ‘No-rule’ strategy. It turned out that 194 geography teachers participated in the survey. The researcher assumed that a sample as large as 194 was representative of a population of 408 geography teachers in the province. Details about ethical issues that were addressed in the study and how they were handled are discussed in the next section.

3.2.2 Addressing Ethical Concerns

In conformity with the axiological principles of responsible indulgence, a number of arrangements were made in an effort to secure ethical clearance for this research. The considerations and arrangements include an application for ethical clearance to the Ethical Screening Committee of the Department of Curriculum Studies, application for access to the site and participants, and obtaining the consent of the participants. Details of the considerations and arrangements are provided below.

On approval of the proposed research by the Department of Curriculum Studies Research Committee, an application for ethical clearance was forwarded to the Departmental Ethical Screening Committee (DESC). To approve research, the DESC considers the real and potential risks associated with it. Thus, risks are categorised into three: low risk, medium risk and high risk. Based on the DESC Guidelines, research is defined as low risk if the only foreseeable risk is one of discomfort or inconvenience. It encompasses research in which the topic is uncontroversial and investigation is by means of surveys, interviews and observation. The participants in low-risk research are adults, even though some research involving children may qualify as low risk at the discretion of the DESC. In low-risk research, the researcher only collects non-sensitive information anonymously. Medium-risk research has a potential risk of harm, but following appropriate steps can alleviate or reduce the entire risk. In high-risk research there is a real and foreseeable risk of harm and discomfort, which could result in serious advert consequences if the researcher fails to take appropriate cautionary measures (University of Stellenbosch Departmental Ethical Screening Committee (DESC), 2012). Following this categorisation of the level of risk, the assessment of the climate change science literacy and climate change pedagogical literacy of geography teachers in the Western Cape was considered 'low-risk' research.

Approval to proceed with the study was granted at a meeting of the Research and Ethics Committee and communicated to the researcher in writing (see approval letter in Appendix 2). With the approval, the researcher proceeded to the Western Cape

Department of Education (WCDE) to seek approval to conduct the research in public schools within the Western Cape. In the application, the researcher provided his personal information, details of the study, such as degree, area of study, supervisors, title of the study, the research questions, aim and objectives of the study, and a copy of the research proposal. Approval was granted to conduct the study (see Appendix 3 for approval letter from the WCDE).

One of the ethical requirements in empirical research is securing the consent of the participants. The issue of consent is critical in research involving humans because research participants have the right to accept or not to accept involvement in the study. The consent form addressed the following issues: the title of the study, the researcher's name and educational background, the purpose of the study, the procedures of the study, potential risks and discomfort, and potential benefits for the participants and/or society. Other ethical issues include payment for participation, confidentiality, participation and withdrawal and identification of the researcher (see the Consent Forms in Appendices 4 and 5).

The next section discusses the development of the research instrument, including the choices that were made in the process and the rationale for these choices.

3.2.3 Instrument Development

Section 1.4 makes it clear that the purpose of the study was to measure the level of climate change science literacy and the level of climate change pedagogical literacy of geography teachers in the Western Cape, including the factors influencing them. Measurement, defined by Iramaneerat, Smith and Smith (2008:50), refers to the assignment of numerals to objects according to rules. This view is similar to that of Bohrnstedt (2010:348), who describe measurement as the assignment of numbers using rules that reflect or correspond to properties of phenomenon or object. The rules of correspondence between manifest observations and the numbers assigned to them define measurement in a given instance. Creswell (2009:6) explains that measurement is identified with a post-positivist worldview, which takes interest in “empirical observation” and “theory formulation”.

3.2.3.1 Assumptions of Measurement

The measurement instrument employed in this study was developed, and important considerations in the development of the assessment instrument were fitness, adequacy and relevance. Issues of instrument fitness, adequacy and relevance are concerned with construct validity, construct validity and face validity. The development of the research instrument was guided by a set of assumptions, including that the constructs must be operationally defined, the answers must be predetermined, and objective comparison must be possible between groups (Bovaird and Embretson, 2009; Scott and Usher, 2000). These requirements were addressed at various stages of the study. For example, the requirement of an operational definition of the constructs was addressed in Chapter 2 in relation to models of climate change science literacy and climate change pedagogy literacy in Figures 5 and 8. The issue of a predetermined answer was addressed used a multiple-choice format, as indicated in the introduction. The issue of objective comparison was addressed in the test of the hypotheses. Based on these requirements, the method of data collection that could fulfil these requirements is the questionnaire, which is a self-reporting instrument consisting of a collection of questions or statements to be put forward to a person or group of persons and for which an answer is required (Babbie and Mouton, 2011).

The choice of a close-ended questionnaire was inspired by the two main objectives of a questionnaire highlighted by Leung (2001:187) as being “to maximize the proportion of subjects (participants) answering our questionnaire – that is, the response rate”, and “to obtain accurate relevant information for our survey”. To collect both quantitative and qualitative data, as required by the study’s design, both questionnaires integrated open-ended and closed-ended questions. Open-ended design, according to Robinson and Lai (2006:116), allows respondents to write what they wish to say in response to an item, while close-ended design requires respondents to express their answers by selecting from a range of predetermined alternatives. Multiple-choice items (MCI) normally comprise one or more introductory sentences (the stem), followed by a list of two or more options. Their scoring is faster, economical, and amenable to statistical analysis and for making objective comparison between individuals or groups (Kominski, 2012; Race, 2005).

There are many possible options in the design of multiple-choice tests. Schwarf and Baldwin (2007) provide three possible options for multiple-choice tests. The first option is the zero penalties, in which the participant is not penalised when an incorrect answer is provided on an item. In the second option, the participant is assessed based on questions that he has attempted and to which he provides answers. In the third option, the participant is penalised for questions he provides incorrect answers to, as well as questions that were not attempted. This study chose the first option, which permits the participants to leave unanswered any questions they do not wish to answer. The advantage close-ended questionnaires have over the open-ended format is they are easy and quick to fill in, minimise discrimination against the less literate (in self-administered questionnaires) or the less articulate (in interview questionnaires). They are also easy to code, record and to analyse the results quantitatively and easy to report results (Leung, 2001:187).

3.2.3.2 Steps Taken to Achieve Measurement Validity

A number of steps were taken to ensure the validity of the measurement instrument. These include ensuring the relevance of the aims of FET Geography in terms of the aims of climate change education, knowledge of the methods of asking geography questions, domain identification and selection of relevant content topics, awareness of the relevance of climate change pedagogy content topics to the implications of climate change education. Other measures taken include constructing valid items, developing a preliminary item-specification table, seeking the opinion of experts in the area of study, piloting the instrument, conducting item analysis, selecting valid items (item sampling), revising the instrument based on the findings from piloting, translating the instrument into Afrikaans, and finalising the item-specification table. Details of these steps are discussed below.

3.2.3.2.1 Relevance of the Aims of FET Geography to the Aims of Climate Change Education

To ensure the relevance of the instrument, the researcher familiarised himself with the aims of the FET Geography curriculum as outlined in the Curriculum and Assessment Policy Statement (CAPS). Some aims of geography in the FET band (Grades 10 to 12) include explaining and interpreting both physical and human geographical processes, describing and explaining the dynamic interrelationship between the physical and human worlds, developing knowledge about where places are, the nature of a range of different places at different scales, developing a commitment towards sustainable development, creating awareness of and sensitivity to inequality in the world, creating empathy, tolerance and fairness, and making and justifying informed decisions and judgement about social and environmental issues (Department of Basic Education, 2011). These aims are related in many ways to the new content and concepts prescribed by UNESCO (2009a) for the development of climate change literacy in schools.

The focus of FET Geography on the Earth and its environment, social equity and problem-solving suggests that geographic concepts, values and skills are relevant for achieving the aim of climate change education. This view is underscored by Robinson (2011:37), who argues that effective climate change education will help students to develop an understanding of the issues around climate change, increase their environmental awareness and develop their personal social responsibility. It is the relationship between the knowledge and competencies that geography education seeks to develop and the knowledge and competencies climate change education seeks to promote that situates this study at the intersection of geography education and climate change education.

3.2.3.2.2 Methods of Asking Geography Questions

The decision to employ a criterion-referenced multiple-choice questionnaire for this study is in keeping with the axiological framework that drives this study. The fact that the participants in this study were geography teachers necessitates that the researcher should be familiar with the way geographers ask questions or inquire about processes, phenomena and issues, as prescribed in the CAPS (Department of Basic Education, 2011a:10). It is suggested that these questions should be used by teachers in their teaching and to help learners to develop conceptual understanding (see Table 3) as they deal with certain geographical topics.

Table 3 also indicates six methods of inquiry or action that are preferred when dealing with certain types of questions. These include observation, description, analysis and explanation, evaluation and prediction, decision making, and making personal evaluation and judgement and providing a substantiated response. This guideline was used as a framework in constructing the items for the questionnaire.

Table 3: Methods of asking Geography questions

Methods of enquiry	Concepts	Key questions
Observation	Physical and human responses, awareness, perception, characteristics and differences	What is? What is it like?
Description	Location, place, region, distribution, pattern, scale and spatial association	Where does it occur? Why is it there?
Analysis and explanation	Interdependence, causes and processes	What happens? Why did it happen? How is it changing?
Evaluation and prediction	Environmental impact, social impact, interdependence, spatial interaction, spatial organisation, human-environment interaction, cause, process, time, behaviour, consequence, justice, quality of life, environmental quality, welfare, costs and benefits	What are the effects? What is likely to happen?
Decision making	Choices, decisions, costs and benefits, planning, management, power, inequality and problem solving	Who benefits? What decisions must be made? What are the costs and benefits of decisions? How should it be managed?
Personal evaluation, judgement and response	Cultural sensitivity, diversity, ethics, opinion forming, empathy, values, action and personal responsibility	What is my position? What action can I take?

3.2.3.2.3 Domain Identification and Selection of Relevant Content Topics

Content topics were selected from the two main domains of the study, namely climate change science and climate change pedagogy.

a) Main Domain 1: Climate Change Science

The main consideration in the selection of content is that the content selected must relate to content in the Continuous Assessment Policy Statements (CAPS) for Grades 10-12 Geography. To facilitate item construction, the climate change science content was categorised into three subdomains. Subdomain 1 (CCS-SD1) refers to climatic processes and probable causes of climate change, Subdomain 2 (CCS-SD2) refers to climate change impact, and Subdo

Table 4: Concepts related to Climate Change Science

	CCS-SD1	CCS-SD2	CCS-SD3
1	The Earth's climate systems	Evidence of climate change on natural/ human systems	Stabilisation of global carbon production
2	Global warming	Climate change and water availability	Rural people and their adaptation to climate change
3	Natural/anthropogenic causes of climate change	Vulnerability of sub-Saharan Africa	Implementation of climate change polices
4	Global CO_2 emissions and future climates	Effect of climate change in developing countries	Mitigation and adaptation options for developing countries, if global warming continues for centuries
5	The nature of climate science	Global effects of climate change	Climate change response instruments

The researcher developed a question from each content topic in Table 4. Following that there are five content topics in each subdomain, the questionnaire contained fifteen items – five items from each subdomain. To ensure the validity of the questionnaire it was important that the content topics in Table 4 from which items were drawn are relevant to the geography content topics for Grades 10 to 12 (FET band). The FET Geography curriculum was designed around four themes, referred to as

Geography's four 'Big Ideas'. These Big Ideas include place, spatial processes, spatial distribution patterns, and human and environment interaction (Department of Basic Education, 2011:8). To determine whether the subdomain topics shown in Table 4 are relevant to FET Geography content topics, an attempt was made to associate domain content topics with geography content topics as outlined in CAPS and in Table 5.

Table 5: Climate Change Science subdomain concepts and related geography content topics

Grade	Geography Content Topic	Related?	CCS subdomain topic
10	Geographical skills and techniques	Yes	CCS-SD1-1, CCS-SD1-2, CCS-SD1-3, CCS-SD1-4
	The composition and structure of the atmosphere	Yes	CCS-SD1-1; CCS-SD1-2; CCS-SD1-4; CCS-SD2-1
	Plate tectonics, faulting, volcanoes and earthquakes	Yes	CCS-SD1-2; CCS-SD2-1; CCS-SD2-2
	Population: structure, growth and movements	Yes	CCS-SD2-1; CCS-SD2-2; CCS-SD3-2; CCS-SD2-4;
	Water resources: oceans, flooding, water management	Yes	CCS-SD1-2; CCS-SD1-3; CCS-SD2-1; CCS-SD2-2; CCS-SD2-4; CCS-SD2-2; CCS-SD3-1; CCS-SD3-2; CCS-SD3-3; CCS-SD3-4
11	Geographical skills/techniques	Yes	CCS-SD2-1, CCS-SD2-2, CCS-SD2-3, CCS-SD2-4, CCS-SD2-5
	Global air circulation, Africa's weather and climate	Yes	CCS-SD1-2; CCS-SD1-3; CCS-SD1-5; CCS-SD2-2; CCS-SD3-4
	Rocks and landforms, slopes and mass movements	Yes	CCS-SD1-2; CCS-SD2-1; CCS-SD2-2
	Development: differences, issues, and opportunities	Yes	CCS-SD2-2; CCS-SD2-3; CCS-SD2-4; CCS-SD3-1; CCS-SD3-2; CCS-SD3-3; CCS-SD3-4; CCS-SD3-5
	Resources and sustainability, soil, energy	Yes	CCS-SD1-4; CCS-SD2-2; CCS-SD2-3; CCS-SD2-4; CCS-SD3-2; CCS-SD3-3; CCS-SD3-4; CCS-SD3-5
12	Geographical skills and techniques: topographic maps, GIS, etc	Yes	CCS-SD3-1, CCS-SD3-2
	Climate and weather: cyclones, local climate	Yes	CCS-SD1-1; CCS-SD1-2; CCS-SD1-3; CCS-SD1-4; CCS-SD1-5; CCS-SD2-3; CCS-SD2-2
	Geomorphology: drainage system and fluvial processes	Yes	CCS-SD1-2; CCS-SD2-1; CCS-SD2-2
	Rural and urban settlements	Yes	CCS-SD2-2; CCS-SD3-2; CCS-SD3-3; CCS-SD3-4
	Economic geography in South Africa	Yes	CCS-SD2-1; CCS-SD2-3; CCS-SD2; CCS-SD2-2-4; CCS-SD3-1; CCS-SD3-2; CCS-SD3-3; CCS-SD3-4; CCS-SD3-5

Table 5 shows that all the subdomain content topics for Grades 10, 11 and 12 are related to geography content topics. This suggests that the CCS content topics listed in Table 4, from which questions were developed to assess literacy in climate change science, are relevant to the geography big ideas.

b) Main Domain 2: Climate Change Pedagogy

As with climate change science literacy, the first step in the construction of the items for assessment of climate change pedagogical literacy was to identify subdomain content topics and to ensure that the content topics are related.

Table 6: Subdomains of Climate Change Pedagogy

CCP-SD1		CCP-SD2
1	Climate change and children	Cognitive conflict and learning
2	Objectives of climate change education	Process of knowledge construction
3	Relationship between climate change and development	Transfer of knowledge
4	Competencies for adaptation to climate change	The process of conceptual change
5	Assessing adaptation options	Meaning and types of assessment

Table 6 shows that a total of 10 content topics for climate change pedagogy were identified, consisting of five content topics for Climate Change Pedagogy Subdomain 1 (CCP-SD1), which are the aims and significance of climate change education, and five content topics for Climate Change Pedagogy Subdomain 2, constructivist teaching principles and practice (CCP-SD2), dealing with the aims and significance of climate change education, and five content topics for constructivist teaching principles and practice. With the subdomain and associated content topics identified, the next step taken by the researcher was ensuring that the CCP content topics were relevant to the implications of climate change for education and learning, and the theories and practice of constructivist teaching. Details of these are provided in the next section.

3.2.3.2.4 Relevance of Climate Change Pedagogy Content Topics to the Implications of Climate Change Education

According to UNESCO (2009b:1), climate change has substantial implications for education and learning. As a result, education needs to take into consideration the following four implication of climate change:

- *Implication 1*: All levels and forms of existing educational, teaching and learning programmes need to be reviewed and re-oriented to address the causes and consequences of climate change.
- *Implication 2*: Climate change requires educators to include new content in education, training and public awareness programmes.
- *Implication 3*: Creativity, problem solving and social transformation skills need to be developed and nurtured.
- *Implication 4*: Positive, participatory action and solution-centred approaches to education and learning need to be developed.

Table 7 illustrates the extent to which the content topics of climate change pedagogy are relevant to these four implications.

Table 7: Relevance of climate change pedagogy content topics to the implications of climate change for education

Subdomains of CCP	**Associated implication**
CCP-SD1	
Impact of climate change on children	Implication 1
Objectives of climate change education	Implication 3
Relationship between climate change and development	Implications 1 and 3
Competencies for adaptation to climate change	Implications 1 and 3
Assessing adaptation options	Implications 1 and 3
CCP-SD2	**Association**
Managing cognitive conflict	Implications 3 and 4
The process of knowledge construction	Implications 3 and 4
Transfer of knowledge/problem solving	Implications 3 and 4
The process of conceptual change	Implications 3 and 4
Teaching and assessment	Implication 4

Table 7 shows that the content topics selected for the assessment of climate change pedagogy are relevant to three of the four implications of climate change for education and learning outlined by UNESCO, particularly Implications 1, 3 and 4. This implies that the content topics for the assessment of climate change pedagogy are 75% relevant to the implications of climate change for education and learning.

With the content topics of climate change science and climate change pedagogy identified and their relevance determined, the next step was to construct the items for the assessment of climate change science literacy and climate change pedagogical literacy.

3.2.3.2.5 Item Construction

Considering that survey research involves asking research participants questions, the research must ensure that the survey instrument is designed in such a way that it invites and sustains the attention and interest of the research participants during the process of data collection. Personal experience shows that research participants are uninterested in a survey that requires them to complete more than one questionnaire. It was for this reason that the researcher decided to produce a questionnaire that measured all three main variables in one instance. It was anticipated that this choice would increase the response rate and reduce cost. Consequently, the questionnaire for this study consists of three main sections. Section 1 is concerned with the background details of the school and geography teachers, Section 2 deals with climate change science, and Section 3 deals with climate change pedagogy.

Section 1 was divided into two parts. The first part (Part A) consists of school-related variables and the second part (Part B) consists of teacher-related variables. The variables in both parts, presented below, are categorical and expected to produce categorical data.

a. <u>School Details</u>

Details about the school constitute Part A of Section 1 of the questionnaire. This part focuses on the following:

i. District where school is situated

- Metropole Central
- Metropole East
- Metropole North

- Metropole South
- West Coast
- Overberg
- Eden-Karoo
- Cape Winelands

ii. School location type

- Rural
- Semi-urban
- Rural

iii. School type

- Boys only
- Girls only
- Mixed (co-educational)

iv. Approximate number of learners

- Fewer than 1 000
- Over 1 000

v. Number of teachers

- Fewer than 30
- Over 30

vi. Number of FET Geography teachers

- 1
- 2
- More than 2

b. <u>Teacher Details</u>

Details about the teachers constitute Part B of Section 1 of the questionnaire. This part focuses on the following teacher variables: gender, age, highest qualification, specialisation and experience. Other variables involved in this part include grade mostly taught, number of learners taught geography, experience in providing instruction on climate change, main source of information on climate change science, and main source of information on climate change pedagogy. As in Part A, the variables in Part B are organised in categories. The items are logically sequenced from very personal issues to less personal issues. The questionnaire was designed in such a way that the various categories are well-demarcated and spaced to make it easy for anyone to read and to make choices accordingly.

i. Gender
- Male
- Female

ii. Age range (in years)
- Less than 25
- 25-40
- Over 40

iii. Highest qualification
- Ordinary Diploma
- Bachelors
- Honours
- Master's
- Doctorate

iv. Subject specialisation
- Geography only
- Geography and Education
- Others

v. Number of years in teaching
- Less than 5 years
- 6-10 years
- More than 10 years

vi. The grade you mostly teach (*Choose one only*)
  - 10
  - 11
  - 12

vii. Number of learners that you teach Geography
- Fewer than 50
- More than 50

viii. a) Experience in providing instruction on climate change

- Yes
- No

b) If your answer to 8a is 'Yes', answer sub-items i and ii (choose one in each case).

ii) Where do you mainly get information on climate change content and concepts?

- Television
- Radio
- Internet
- School textbooks
- Workshops and seminars
- Peers/subject advisors

ii) Where do you mainly get information on methods of teaching climate change?

- Television
- Radio
- Internet
- School textbooks
- Workshops and seminars
- Peers/subject advisors

A pool of items was developed consistent with the domains of climate change science and climate change pedagogy, as indicated in section 3.2.3.2.3 in this chapter. An important consideration in the construction of the items was ensuring that the items varied in their level of cognition based on the cognition levels of literacy presented in Figure 2 in Chapter 2, which highlights the three levels of literacy as factual, conceptual and procedural. Factual questions are questions that require the respondent to identify concepts and use terminology correctly. Conceptual questions require the respondent to categorise objects, places, events and time based on principles, and to make generalisations, formulate theories, build models and make inferences. Procedural questions require the respondents to demonstrate awareness of methods of solving specific problems, to determine where, when and how specific methods and procedures can be used, and to solve specific problems. This cognition level mix is an attempt to ensure that the questions are not too easy that all the respondents get all the items correct, or too difficult that all or most of the respondents score very low. Rather, this measure ensured that only those who are literate in climate change science and climate change pedagogy scored high on the test and those who are not literate in the two domains scored poorly.

In an attempt to ensure that the participating teachers had an opportunity to air any other information, it was decided to include space on the last page for further comments that could be used to review the questionnaire after piloting. The participants were to complete this part after they had responded to the items in the three main sections of the questionnaire. The respondents were asked whether the instructions were confusing or clear; whether the length of the questionnaire was lengthy or short; whether the questions were too difficulty of too easy; and whether the wording was easy to understand or not. Space was also provided for the respondents to raise any other suggestions that could help to improve the quality of the questionnaire.

3.2.3.2.6 Preliminary Item-specification Table

The next step taken by the researcher was to develop two preliminary item-specification tables – one for items on climate change science (see Table 8) and the other for items on climate change pedagogy (see Table 9).

Table 8: Preliminary specification table: Part B - Climate Change Science

Sub-domain	Item	Relevant content topic	Cognition Level			Key
			Factual 1	Conceptual 2	Procedural 3	
Climatic processes and probable causes of climate change	QUESTION 1	CCS-SD1-1	X			D
	QUESTION 2	CCS-SD1-1	X			C
	QUESTION 3	CCS-SD1-2		X		B
	QUESTION 4	CCS-SD1-2		X		A
	QUESTION 5	CCS-SD1-2	X			D
	QUESTION 6	CCS-SD1-3		X		D
	QUESTION 7	CCS-SD1-3			X	C
	QUESTION 8	CCS-SD1-3		X		B
	QUESTION 9	CCS-SD1-3		X		B
	QUESTION 10	CCS-SD1-4	X			C
Climate change impacts	QUESTION 11	CCS-SD2-1	X			A
	QUESTION 12	CCS-SD2-2	X			A
	QUESTION 13	CCS-SD2-2			X	D
	QUESTION 14	CCS-SD2-2			X	C
	QUESTION 15	CCS-SD2-5		X		A
	QUESTION 16	CCS-SD2-5		X		B
	QUESTION 17	CCS-SD2-5		X		C
	QUESTION 18	CCS-SD2-5		X		B
	QUESTION 19	CCS-SD2-4		X		A
	QUESTION 20	CCS-SD2-5		X		D
Climate change responses	QUESTION 21	CCS-SD3-2			X	D
	QUESTION 22	CCS-SD3-2			X	B
	QUESTION 23	CCS-SD3-4			X	A
	QUESTION 24	CCS-SD3-1		X		C
	QUESTION 25	CCS-SD3-3			X	A
	QUESTION 26	CCS-SD3-1			X	B
	QUESTION 27	CCS-SD3-1		X		B
	QUESTION 28	CCS-SD3-4			X	C
	QUESTION 29	CCS-SD3-2			X	C
	QUESTION 30	CCS-SD3-5	X			B

Table 8 shows that Part B of the questionnaire contained thirty questions. Questions 1 to 10 relate to Subdomain 1 (climatic processes and probable causes of climate change), Questions 11 to 20 relate to Subdomain 2 (climate change impacts), and Questions 21 to 30 relate to Subdomain 3 (climate change responses).

Table 9: Preliminary specification table: Part C - Climate Change Pedagogy

Sub-domain	Item	Relevant content topic	Cognition Level			Key
			Factual 1	Conceptual 2	Procedural 3	
Aim/significance of climate change education	QUESTION 1	CCP-SD1-1		X		B
	QUESTION 2	CCP-SD1-2		X		D
	QUESTION 3	CCP-SD1-2	X			C
	QUESTION 4	CCP-SD1-3		X		A
	QUESTION 5	CCP-SD1-4			X	D
	QUESTION 6	CCP-SD1-4			X	B
	QUESTION 7	CCP-SD1-4			X	A
	QUESTION 8	CCP-SD1-4			X	C
	QUESTION 9	CCP-SD1-5			X	D
	QUESTION 10	CCP-SD1-5			X	A
Constructivist teaching principles and practices	QUESTION 11	CCP-SD2-2			X	A
	QUESTION 12	CCP-SD2-3		X		C
	QUESTION 13	CCP-SD2-1		X		D
	QUESTION 14	CCP-SD2-2			X	C
	QUESTION 15	CCP-SD2-2			X	B
	QUESTION 16	CCP-SD2-3			X	D
	QUESTION 17	CCP-SD2-3			X	D
	QUESTION 18	CCP-SD2-2			X	A
	QUESTION 19	CCP-SD2-4			X	C
	QUESTION 20	CCP-SD2-5			X	D

Table 9 shows that there are twenty items on climate change pedagogy. Questions 1 to 10 constitute Subdomain 1 (aim and significance of climate change education) and Questions 11 to 20 constitute Subdomain 2 (constructivist teaching principles).

The finalised draft of the questionnaire was discussed with the supervisors before proceeding to seek the opinions of the experts in the field of study.

3.2.3.2.7 Opinion of the Experts

The choice to seek the opinions of experts in climate change science and pedagogy was to fulfil the face validity requirement. Face validity is an estimate of the degree to which a measure is clearly and unambiguously tapping the construct it purports to assess, or simply the obviousness of a test – the degree to which the purpose of the test is apparent to those taking it. A test is said to have high face validity if the purpose is clear, even to naïve respondents, and low face validity if the purpose is unclear (Bornstein, 2004; Yaghmale, 2003). For Teddlie and Tashakkori (2009), face validity is not a true indicator of the validity of an instrument. The researcher agrees with the authors in the sense that, except where those who make the judgement are conversant with the nature of the constructs, the purpose of the study and the test blueprint, it will be difficult for them to make sound judgements concerning the instrument. Teddlie and Tashakkori (2009) therefore advise that researchers should not depend exclusively on face validity to determine the validity of their instruments. Neuman (2011:212) argues that the face validity of an assessment instrument can be determined by the extent to which the indicators make sense as measures of a construct in the judgment of the scientific community. The notion of scientific community here refers to knowledgeable individuals or experts in the discipline in which the study is conducted. Burns and Grove (2001) recommend five experts, whereas Wilson (1989) recommends between five and ten experts.

The initial draft of the questionnaire consisted of fifty-two items on climate change science and twenty-seven items on climate change pedagogy. The items included factual, conceptual and procedural items and were derived from the content topics on climate change science and climate change pedagogy. The idea of producing a pool of items was to ensure that a sufficient number of valid items could be identified. This initial draft of the questionnaire was discussed with my supervisors. An agreement was reached between me and my supervisors that it would be worthwhile to seek the views of experts in the fields of climate change and pedagogy on the validity of the items. Following this suggestion, eight climate change scientists and two pedagogists at various universities and research institutes in South Africa (the University of Cape Town, Stellenbosch University, the University of Johannesburg and the University of KwaZulu-Natal), the CSIR in Pretoria and two climate change scientists from the United Kingdom were requested to critically evaluate the questionnaire. Six of them assessed the questionnaire and forwarded their judgements.

The researcher read all the comments carefully and noted some key points. Some of the assessors focused on conceptual issues on climate change science and climate change pedagogy, while others focused on the format, language, length of the questionnaire and other technical details. One of the assessors stressed the need to ensure that the respondents did not consult texts or online sources when answering the survey. Another remarked that it could be interesting if the research focused on the province as a whole. With these comments, a meeting was arranged with the researcher's supervisors to discuss the comments. It was agreed at the meeting that only valid items should be selected. Based on the comments, the questionnaire was revised and the items were thinned down from fifty-two to thirty for climate change science and from twenty-seven to twenty for climate change pedagogy, with ten items in each subdomain (see Pilot Questions in Appendix 6).

3.2.3.2.8 Instrument Piloting

For this study, the idea with piloting was to identify the deficiencies of the questionnaire prior to employing it for the full-scale survey. Piloting served to reveal weak items so that they could be removed from the questionnaire. This was done with the intention that, after piloting and item analysis, only valid items should be retained to ensure that the questionnaire measured what it was designed to measure.

The questionnaire was piloted on 15 geography teachers, representing about 3.67% of the population of geography teachers in the province and about 7.73% of the intended sample. This decision is consistent with Thabane (2010:5), who emphasises that, even while it is important that the sample size for piloting should be representative of the target population, sample size calculations may not be required for all pilot studies. Smaller samples can be used when the objective of piloting is to ensure internal validity of an instrument. However, opinions vary among methodologists about what is an appropriate sample size for piloting. According to Nieswiadomy (2002), ten participants are adequate for piloting. Lackey and Wingate (1998) recommend 10% of the intended sample. The pilot sample for this study met the requirement set by Nieswiadomy (2002) but did not fulfil that of Lackey and Wingate (1998). Fain (2010) cautions against the use of a small sample for piloting as a small sample lacks statistical power for making generalisations to the larger population of interest. Taking into account that the purpose of piloting in this study was to strengthen the measurement instrument prior to full-scale data collection, a sample size of 10 for piloting might not have any negative effect on the results of the study. Part of the rationale for this decision stems from rather ensuring a larger sample size when the full-scale data collection is done.

All 15 participants involved in the piloting process were teaching in schools located in the Cape Winelands education district. The reason for this was a matter of convenience – all the participating teachers attended workshops and seminars at Stellenbosch University, which made it easier to approach the teachers who would otherwise be teaching kilometres away from each other. While some of the participants completed the questionnaire after their workshop, there were some who requested the researcher to bring the questionnaire to their schools. These teachers came from different schools in the district and did not often meet each other, except at occasions like seminars and workshops.

The way and manner in which piloting was conducted eliminated the risk of contamination of the sample. According to Van Teijlingen and Hundley (2001), contamination of a sample occurs when research participants who have already been exposed to piloting got involved in the full-scale data collection. The participants gave their consent to take part in the study by completing the Consent Forms (see Appendices 5 and 6). Through careful recording of the names and details of the teachers who took part in the piloting, it was possible to avoid any geography teacher who participated in piloting from also taking part in the full-scale study. At the end of piloting, the researcher proceeded with item analysis.

3.2.3.2.9 Item Analysis

The first step in item sampling was quantitative and qualitative analysis of the data from piloting. Quantitative analysis was done by drawing a matrix that shows the keyed options, number of correct responses, facility index and discrimination index for each question. On the other hand, qualitative analysis was done on the basis of comments made by the 15 respondents concerning the instructions, length of the questionnaire, difficulty level of the items, the wording/language of the questionnaire, and other comments after they had completed the questionnaire.

a. Quantitative Analysis

i. Quantitative Analysis of Climate Change Science items

Climatic Processes and Probable Causes of Climate Change

Table 10: Facility Index and Discrimination Index for items of CCS Subdomain 1

Question	N-Correct	Facility Index	Discrimination Index
1	11	0.73	0.15
2	0	0	0
3	10	0.67	0.31
4	10	0.73	0.45
5	6	0.4	0.43
6	9	0.6	0.65
7	11	0.73	0.15
8	15	1	0
9	8	0.53	0.72
10	7	0.47	0.08

Table 10 displays the items, keyed options, number of respondents who answered each item correctly, Item Facility Index and Item Discrimination Index for the 10 items that measured literacy in climatic processes and probable causes of climate change. Since study takes item facility values ranging from 0.20 to 0.70 as acceptable, items 3, 5, 6, 9 and 10 have an acceptable facility index, whereas items 1, 2, 4, 7 and 8 have poor facility index. Item 2 stood out completely, as all the 15 respondents got it wrong. Conversely, based on an acceptable Discrimination Index range of 0.20 and 0.80 for this study, the table indicates that items 1, 2, 7, 8 and 10 have poor discrimination, while items 3, 4, 5, 6 and 9 have good discrimination. Therefore, the results of piloting indicate that items 1, 2, 7, 8 and 10 should be revised or changed.

Climatic Change Impacts

Table 11: Facility Index and Discrimination Index for items of CCS Subdomain 2

Item	N-Correct	Facility Index	Discrimination Index
11	15	1.00	0
12	12	0.8	0.67
13	2	0.13	0.35
14	8	0.53	0.28
15	13	0.87	0.3
16	11	0.73	0.34
17	4	0.36	0.68
18	11	0.73	0.64
19	17	0.47	0.46
20	12	0.8	0.2

Table 11 presents a similar process as was done with the 10 items that measure literacy in climatic processes and probable causes of climate change. Since this study takes Facility Index values ranging between 0.20 and 0.70 as an acceptable range, items 14, 15, 17 and 18 were identified as good items, while items 11, 12, 13, 15, 16 and 18 were identified as not quite good. Items 11 and 12 are interesting in the sense that all 15 respondents got item 11 correct and only two respondents got item 12 correct. Besides item 11, all items in this section had acceptable discrimination indices, as they fell between 0.2 and 0.8.

Climatic Change Responses

Table 12: Facility Index and Discrimination Index for items of CCS Subdomain 3

Item No.	**N-Correct**	**Facility Index**	**Discrimination Index**
21	6	0.4	0.61
22	4	0.27	0.55
23	9	0.6	0.22
24	10	0.67	-0.29
25	7	0.47	-0.16
26	4	0.27	0.09
27	7	0.47	0.38
28	5	0.33	0.14
29	14	0.93	0.43
30	3	0.20	0.20

Table 12 shows that, except for item 9 with a Facility Index of 0.93, all the rest of the items testing literacy in climate change response had a Facility Index falling between 0.2 and 0.7, which suggests that nine out the ten items in this section are good items. Concerning item discrimination index, items 21, 22, 23, 27, 29 and 30 showed good discrimination, while items 24, 25, 26 and 28 showed poor discrimination. Based on this analysis, the items with poor discrimination are not valid.

ii. Quantitative Analysis of Climate Change Pedagogy Items

Aims and Significance of Climate Change Education

Table 13: Facility Index and Discrimination Index for items of CCP Subdomain 1

Item No.	N-Correct	Facility Index	Discrimination Index
1	6	0.4	0.01
2	8	0.5	0.6
3	7	0.5	0.4
4	11	0.8	0.1
5	13	0.9	0.2
6	7	0.5	0.1
7	13	0.9	0.2
8	5	0.3	0.3
9	4	0.3	0.1
10	2	0.1	0.2

Table 13 shows that items 1, 2, 3, 6, 8 and 9 had an acceptable Facility Index, suggesting that the items were neither too easy nor too difficult to answer. Items 4, 5 and 7 were too easy, with many respondents keying in the correct answer, whereas item 10 was too difficult with only two respondents getting the correct answer.

Constructivist Teaching Principles

Table 14: Facility Index and Discrimination Index for items of CCP Subdomain 2

Item No.	N-Correct	Facility Index	Discrimination Index
11	13	0.9	0.5
12	10	0.7	0.6
13	9	0.6	0.5
14	4	0.3	0.3
15	2	0.1	0.1
16	4	0.3	0.1
17	13	0.9	0.7
18	11	0.7	0.3
19	8	0.5	0.4
20	7	0.5	0.2

Table 13 shows that three items measuring literacy in constructivist teaching principles had a Facility Index outside the acceptable range of 0.2 to 0.7. These include items 11, 15 and 17, with items 11 and 17 being too easy and item 15 too difficult. Items 12, 12, 14, 16, 18, 19 and 20 fell within the acceptable Facility Index. Conversely, items 11, 12, 13 14, 17, 18, 19 and 20 had acceptable discrimination, whereas items 15 and 16 did not.

b. Qualitative Analysis

Comments made by the 15 respondents that participated in the pilot study concerning the instructions, length of the questionnaire, difficulty level of the items and wording/language of the questionnaire after attempting the questions, are discussed below.

Instructions

Table 15: Comments about the instructions

Category	Number of respondents
Instructions are confusing	5 (33.33%)
Instructions are clear	10 (66.67%)

The data in Table 15 shows that 33.33% of the respondents were of the view that the instructions were confusing, while 66.67% were of the view that the instructions were clear. On the basis of the majority, this study concluded that the instructions in the questionnaire were clear and understandable.

Length of Questionnaire

Table 16: Comments about the length of the questionnaire

Category	Number of respondents / (%)
Too long	8 (55.33%)
Too short	-
Suitable	7 (44.67%)

The data in Table 16 shows that 55.33% of the respondents held that the questionnaire was too long, while 44.67% of them were of the opinion that the questionnaire was suitable. None described the questionnaire as too short. Based on the evidence presented, this study concludes that the questionnaire was too long.

Difficulty Level of Items

Table 17: Comments about the difficulty level of the items

Category	Number of respondents
Too easy	-
Too difficult	3 (20%)
Suitable	12 (80%)

The data in Table 17 shows that 20% of the respondents believed that the items of the questionnaire were too difficult, while 80% of them reported that the items were suitable. None described the items as too easy. On the basis of the majority, this study concludes that the items of the questionnaire were suitable (not too difficult).

Language/Wording of Items

Table 18: Comments about the wording of items

Category	Number of respondents
Easy to understand	3 (20%)
Difficult to understand	12 (80%)

The data in Table 18 shows that 20% of the respondents maintained that the language of the questionnaire was easy to understand, while 80% of them believed that the language of the questionnaire was difficult to understand. This study therefore concludes on the basis of the data in Table 18 that the language of the questionnaire was difficult.

Other Comments

Other comments provided by the respondents repeated their earlier opinions. Almost all of the respondents described the language of the questionnaire as wordy and difficult, making the items difficult to understand. Notable are the remarks of Respondents 1, 7, 12 and 13. Respondent 1 remarked: "The questions in Subsection B, especially, are not always clear. Perhaps rephrasing them and simplifying them will help." Similarly, Respondent 7 stated: "Questions are well-organised and I believe will achieve its aim. It carries some fundamental knowledge as well as some complex knowledge. Occasionally I struggled to understand what a question was asking. Some questions are too wordy." Respondent 12 remarked: "Some concepts may be difficult to understand for second language speakers, considering the way sentences are formulated and the vocabulary used. The questionnaire is too long and may cause one to lose focus. The last section is difficult due to academic concepts." Finally, Respondent 13 commented: "I felt like my vocabulary was tested more than the actual concept of climate change."

With reference to the comments provided by the respondents, this study concludes that the instructions in the questionnaire were clear and understandable; however, the questionnaire was too long and, while the items of the questionnaire were suitable, they were not too easy and not too difficult. Finally, the language of the questionnaire was wordy and difficult. These findings were taken into consideration in the revision of the questionnaire.

As part of the process of achieving validity, a copy of the questionnaire was sent to an English language specialist at Stellenbosch University, without letting her know the results of the piloting process. The specialist took two days to respond and commented as follows:

“This was a tricky task, as mostly the writing was clear, but the subject concept knowledge and terminology are inextricably entwined in the questions. Where concepts are more complex, the language to express them is often necessarily also complex as there are a greater number of subject specific jargon words and phrases per sentence. I would say that a competent Geography teacher should be able to cope with most of the questions, but for someone less solidly grounded, the combination of answering in a second language and weaker subject knowledge would be a difficult hurdle to overcome.” She made the following suggestions:

1) “Simplify the layout of the multiple choice questions and the answer box so it is very clear you only want one answer, and that it must be written in a box, not circled (though your pilot study would have showed you if this was clear enough or not);

2) Try, if possible to reduce the number of questions phrased in the negative (e.g. this is NOT an example of...) as positive formulations of statements or questions have been shown to be easier for the brain to process while reading.

3) Do not provide much more information in the preamble to the question than the question requires (the question with the table). The more information you provide, the greater the language and conceptual juggling act for the respondent.

4) Otherwise, I would say that someone complaining of the difficulty of the questions might be just as much struggling with the necessary conceptual knowledge, as the two are so intertwined at this educated level of thinking.”

Key issues emerging from the comments provided by the language expert are as follows:

- Layout of the questionnaire
- Phrasing of questions
- Eliminate unimportant preambles

These issues and suggestions were taken into account in revising the instrument.

While I was administering the questionnaire during the pilot stage, I made some personal observations: As soon as the respondents received the questionnaire and skimmed through it, some of them heaved a sigh, while others muttered words that were visible from their lip movements and also their facial expressions. While attempting the questions, some of the respondents again scanned through the pages and scratched their heads. I also observed that some of the respondents completed the questionnaire in 40 minutes, while others spent up to one hour. It began to dawn on me that steps must be taken to reduce the number of items. The issue of reducing the length of the questionnaire was addressed during item sampling.

3.2.3.2.10 Item Sampling

Item sampling involves discarding irrelevant items, including items that do not perform as expected; revising relevant but poorly constructed items; and adding new items, particularly for subdomains that were not adequately covered. Taking into consideration the reactions of the respondents while they were attempting the questions, the comments provided by the respondents after attempting the questions, the results of the quantitative analysis (Facility Index and Discrimination Index) of the items, and the comments of the various experts whose comments were sought, modifications were made to the instructions, the format of the questionnaire and the length of the questionnaire.

Some items in the piloted questionnaire were rejected based on the outcomes of item analysis, mainly items with a high facility index and low discrimination index. By rejecting these items, the number of items was reduced to half of the piloted items. Details of the items retained and the rationale for their retention were provided in Table 19.

Table 19: Rejected and retained items on climatic processes and probable causes of climate change

Item	FI	DI	Decision	Rationale	Item No.
1	0.73	0.15	Reject	High facility/low discrimination	-
2	0	0	Modify and retain	To expose misconceptions	1
3	0.67	0.31	Reject	Testing same concept as Q2	-
4	0.73	0.45	Reject	High facility	-
5	0.4	0.43	Retain without modification	Good facility and discrimination	2
6	0.6	0.65	Modify and retain	Good facility and discrimination	3
7	0.73	0.15	Reject	High facility and low discrimination	-
8	1	0	Modify and retain	Testing important concept	4
9	0.53	0.72	Retain without modification	Good facility and discrimination	5
10	0.47	0.08	Reject	Low discrimination	-

Table 19 shows that, out of the ten items on climatic processes and probable causes of climate change piloted, five were rejected, three were modified and retained and two were retained without modification. The five items retained from this section after piloting are as follows:

2. One of these options is the most abundant greenhouse gas and also the most important contributor to natural greenhouse effect.

☐ **A**. Methane
☐ **B**. Carbon dioxide
☐ **C**. Water vapour
☐ **D**. Nitrous oxide

5. The term *global warming* refers to

☐ **A**. a high concentration of carbon dioxide in the lower atmosphere
☐ **B**. rapid changes in dynamics and processes of the climate system
☐ **C**. changes in global climate and local weather patterns
☐ **D.** increase in the average temperature of the Earth's atmosphere

6. Which of the options below is an anthropogenic cause of climate change?

☐ **A**. Slow drifting of continents over millions of years
☐ **B**. Inconstant intensity of radiation emitted by the sun
☐ **C**. Volcanic eruptions that inject ash and sulphur compounds into the atmosphere
☐ **D.** Release of industrial greenhouse gases into the lower atmosphere

8. Which of these statements is correct, given the amount of CO_2 currently in the Earth's atmosphere?

☐ **A**. There will be a reduction of global warming in the next few decades
☐ **B**. Global warming will continue for many centuries
☐ **C**. Developing countries will experience less warming
☐ **D**. Highly industrialised countries will experience less warming

9. Climate change science is characterised by

☐ **A**. precision
☐ **B**. uncertainty
☐ **C**. consensus
☐ **D**. feedback

Table 20: FI and DI for items on climate change impacts

Item	FI	DI	Decision	Rationale	Item
11	1.00	0	Modified and retained	Conceptual	6
12	0.8	0.67	Rejected	Soft item	-
13	0.13	0.35	Rejected	Too hard an item	-
14	0.53	0.28	Retained without modification	Moderate item	7
15	0.87	0.3	Rejected	Soft item	-
16	0.73	0.34	Modified and retained	Moderate	8
17	0.36	0.68	Modify and retain	Hard item, conceptually good	9
18	0.73	0.64	Modified and retained	Conceptual	10
19	0.47	0.46	Rejected	Conceptual	-
20	0.8	0.2	Rejected	Conceptual	-

Table 20 shows that five items were selected after piloting to measure literacy in climate change impact. Four items were modified and retained and one was retained without modification. The five items retained in this section are as follows:

11. One of the options below is an evidence of global warming.

- ☐ **A**. Decrease in ice sheets
- ☐ **B**. Decrease in global temperature
- ☐ **C**. Decrease in sea level
- ☐ **D**. Decrease in ocean salinity

14. Atmospheric supply of moisture in an area minus atmospheric demand for moisture in that area can give an indication of

- ☐ **A**. heat waves
- ☐ **B**. disease outbreaks
- ☐ **C**. droughts
- ☐ **D**. floods

16. Most sub-Saharan African countries are vulnerable to climate change because they have

- ☐ **A**. low CO_2 emissions per capita
- ☐ **B**. poor capacity to adapt to climate changes
- ☐ **C**. high CO_2 emissions per capita
- ☐ **D**. good capacity to adapt to climate changes

17. Which of these options is **not** caused by climate change in less developed countries?

- ☐ **A**. Low out-migration
- ☐ **B**. Low income opportunities
- ☐ **C**. Low outbreak of diseases
- ☐ **D**. Poor service delivery

18. Too much heat due to an increase in greenhouse warming may have a more negative effect on people in the northern hemisphere than people in the southern hemisphere because

- ☐ **A**. the northern hemisphere lacks the technology to deal with global warming
- ☐ **B**. the northern hemisphere is more populated than the southern hemisphere
- ☐ **C**. the southern hemisphere is more populated than the northern hemisphere
- ☐ **D**. the southern hemisphere is less vulnerable to global warming impacts

Table 21: FI and DI for items on climate change responses

Item	FI	DI	Decision	Rationale	Item No
21	0.4	0.61	Reject	Conceptual	-
22	0.27	0.55	Retain without modification	Good	12
23	0.6	0.22	Reject	Conceptual	-
24	0.67	-0.29	Reject	Conceptual	-
25	0.47	-0.16	Retain without modification	Good	13
26	0.27	0.09	Reject	Too hard	-
27	0.47	0.38	Retain without modification	Good	11
28	0.33	0.14	Modify and retain	Good	14
29	0.93	0.43	Reject	Too soft	-
30	0.20	0.20	Modify and retain	Good	15

Table 21 shows that, of the five selected items, three were retained without modification, while two were modified and retained. The five selected items are as follows:

22. The term ‘carbon sequestration’ means

☐ **A**. interruptions of the carbon cycle by human beings
☐ **B**. the removal of CO_2 from the atmosphere and depositing it in reservoirs
☐ **C**. flow of CO_2 through the oceans, biosphere and lithosphere
☐ **D.** production of large quantities of CO_2 from industrial processes

25. One of these is **not** a community-based adaptation to climate change.

☐ **A**. Implementing projects aimed at poverty eradication
☐ **B**. Implementing guidelines to achieve carbon emission reduction targets
☐ **C**. Establishing disaster-risk reduction centres in rural areas
☐ **D**. Encouraging local people’s participation in natural resource conservation

27. Which of these may hinder the implementation of new policies on climate change?

☐ **A**. Ensuring that climate experts alone formulate climate change policies
☐ **B**. Enhancing the capacity of the media to educate communities about climate change
☐ **C**. Involving rural communities in climate change discourse
☐ **D**. Educating children and youth about climate change

28. Which of the options below is the best for developing countries, if climate change does not stop soon?

☐ **A**. Reduce the amount of greenhouse gas in the atmosphere
☐ **B**. Carry on with business as usual until climate change stops
☐ **C**. Implement programmes that will reduce the harmful effect of climate change
☐ **D**. Search for more scientific information on present and future climate changes

30. One of these initiatives is associated with South Africa.

☐ **A**. COP16/CMP6
☐ **B**. COP17/CMP7
☐ **C**. COP18/CMP8
☐ **D**. COP19/CMP9

In total, Section 2 of the questionnaire, which measures literacy in climate change science, consisted of fifteen items, with five items for each subdomain.

Table 22: FI and DI for items on aim and significance of climate change education

Item	FI	DI	Decision	Rationale	Item No
1	0.4	0.01	Revise and retain	Core concept	1
2	0.5	0.6	Revise and retain	Core	2
3	0.5	0.4	Reject	Conceptual	-
4	0.8	0.1	Revise and retain	Conceptual	3
5	0.9	0.2	Reject	Soft	-
6	0.5	0.1	Reject	Conceptual	-
7	0.9	0.2	Reject	Soft	-
8	0.3	0.3	Modify and retain	Conceptual	4
9	0.3	0.1	Revise and retain	Conceptual	5
10	0.1	0.2	Reject	Too hard. Conceptual	-

Table 22 shows that, of the five items selected from the pilot pool, four were revised and retained while one was retained without modification. The five selected items are as follows:

1. Children are the most affected by climate change because

☐ **A**. the population of children and young people is large
☐ **B**. children have limited access to resources
☐ **C**. most parents do not take proper action to protect their children
☐ **D**. many children in schools lack discipline

2. Which of the options below **is not** an objective of climate change education?

- ☐ **A**. Helping learners to understand the causes and effects of climate change.
- ☐ **B**. Empowering learners to take actions that will help them to adapt to climate change.
- ☐ **C**. Enabling learners to debate issues relating to climate change.
- ☐ **D**. Empowering learners to decide on new policies on climate change

4. Teaching learners that social equality in society can be achieved when natural resources are managed effectively will help them understand that

- ☐ **A**. society, natural resources and development are connected
- ☐ **B**. natural resources cannot be exhausted
- ☐ **C**. society does not require natural resources to achieve social equality
- ☐ **D.** development, society and natural resources are unrelated

8. One of the options below is not a mathematical skill needed for conducting climate change vulnerability analysis.

- ☐ **A**. Inferential reasoning
- ☐ **B**. Measurement
- ☐ **C**. Identifying issues
- ☐ **D**. Modelling

9. Assessing a variety of climate change adaptation options, choosing the best from among the options, and being aware of consequences of the choices that one makes are examples of

- ☐ **A**. information processing
- ☐ **B**. dialogic negotiation
- ☐ **C**. knowledge construction
- ☐ **D**. decision making

Table 23: FI and DI of items on constructivist teaching principles

Item	FI	DI	Decision	Rationale	Item No
11	0.9	0.5	Reject	Too soft	-
12	0.7	0.6	Reject	Conceptual	-
13	0.6	0.5	Revise and retain	Conceptual	6
14	0.3	0.3	Retain	Good	7
15	0.1	0.1	Reject	Too hard	
16	0.3	0.1	Revise and retain	Conceptual	8
17	0.9	0.7	Reject	Soft	-
18	0.7	0.3	Reject	Conceptual	-
19	0.5	0.4	Revise and retain	Good	-
20	0.5	0.2	Revise and retain	Good	-

Table 23 shows that, of the five items selected from the pilot item pool four were revised and retained while one was retained without revision. The five retained items are as follows:

13. A learner read from a textbook that the global climate pattern is changing and humans are the main cause. Yet, this learner still doubts that there is enough proof in his or her location that requires taking immediate action. The situation that this learner finds him or herself is called

- ☐ **A**. cognitive apprenticeship
- ☐ **B**. cognitive autonomy
- ☐ **C**. cognitive load
- ☐ **D**. cognitive conflict

14. One of the teachers in your school often complains that some learners have difficulty in constructing their own ideas when learning new concepts relating to climate change. Which of these strategies should this teacher emphasise in future lessons?

- ☐ **A**. Making judicious use of learning time
- ☐ **B**. Completing tasks independently
- ☐ **C**. Predicting the trends of future events
- ☐ **D**. Thinking before providing answers to questions

16. A teacher often gives his or her learners tasks and conditions similar to those that they will meet later in their home environment. This teacher's effort is likely to promote

- ☐ **A**. concept learning
- ☐ **B**. cooperative learning
- ☐ **C**. inquiry learning
- ☐ **D**. transfer of learning

19. Which of the sequences listed below can a teacher apply to change the faulty concepts learners hold about global warming?

- ☐ **A.** Investigate → Transfer → Hypothesise → Review
- ☐ **B.** Review → Hypothesise → Transfer → Investigate
- ☐ **C.** Hypothesise → Investigate → Review → Transfer
- ☐ **D.** Transfer → Review → Investigate → Hypothesise

20. Some learners in a class performed poorly in previous assessments on the causes and effects of climate change. Which of these assessment forms provides the greatest opportunity for learners to close the gap in their understanding?

- ☐ **A.** Diagnostic assessment
- ☐ **B.** Summative assessment
- ☐ **C.** Baseline assessment
- ☐ **D.** Formative assessment

At the end of item sampling, a total of ten items were selected to measure literacy in climate change pedagogy, which constitutes Section 3 of the questionnaire and was used in the full-scale study. See the copy of the questionnaire for the full-scale study in Appendices 6 and 7. The reliability coefficient of the instrument was computed with data gathered during the full-scale study.

3.2.3.2.11 Revision of the Instrument

Three key aspects of Section 1 of the questionnaire were also revised. These were the instructions, background details and the layout of the questions.

The instructions were revised to convey to the respondent that the questionnaire was divided into sections, namely:

- Section 1: Background of the school and the teacher
- Section 2: Climate change science
- Section 3: Teaching of climate change (pedagogy)

The instructions also advised the respondent to attempt all questions in the three sections independently. Issues of anonymity and confidentiality were emphasised, as the respondent was advised not to write his/her name or the name of the school on the questionnaire. The respondent was further reassured that the information given in this questionnaire would be used for research purposes only and would remain confidential. Besides general instructions, further instructions were provided at the beginning of each section to guide the respondent on how to approach the questions in each section. For example, in Section 1 (Background details of school and the teacher) the instruction reads:

'Insert √ (a tick) close to information that applies to you. Choose one option in each case'.

For Section 2 the instruction reads:

'Each question in this section has four options lettered A to D and one of the options is the most correct answer. Insert X in the box in front of the most correct answer'.

Although Sections 2 and 3 adopted the same format, instructions were provided for Section 3 to reinforce the earlier instruction, and it read:

'Each question in this section has four options lettered A to D and one of the options is the most correct answer. Insert X in the box in front of the most correct answer, as in Section 2'. These details were provided in simple language with precision to ensure that the respondent understood exactly what was required in each section and could respond accordingly, and in this way reduce test anxiety, which may be associated with difficulty to understand what is expected, and to minimise the chances of the respondents making mistakes.

The background details of the school and the teacher were also revised. Initially, both sections were lumped together, which appeared bulky at first glance. In the revised version, school details were separated from teacher details, allowing a transition from one part to another, as shown in Figures 11 and 12.

1. District where school is situated	Metro Central	Metro East	Metro North	Metro South
	West Coast	Overberg	Eden & Central Karoo	Cape Winelands
2. School location type	Rural	Semi-urban	Urban	
3. School type	Boys only	Girls only	Mixed (Co-educational)	
4. Approximate number of learners	Fewer than 1000	Over 1000		
5. Number of teachers	Fewer than 30	Over 30		
6. Number of FET Geography teachers	1	2	More than 2	

Figure 11: School details

All items in Figure 11 relate to school characteristics, while all items in Figure 12 relate to teacher characteristics.

<table>
<tr><td colspan="2">1. Gender</td><td colspan="2">Male</td><td colspan="2">Female</td></tr>
<tr><td colspan="2">2. Age range (in years)</td><td>Less than 25</td><td colspan="2">25-40</td><td>Over 40</td></tr>
<tr><td colspan="2" rowspan="2">3. Highest qualification</td><td>Ordinary Diploma</td><td colspan="2">Bachelor Degree</td><td>Honours Degree</td></tr>
<tr><td>Postgraduate Diploma</td><td colspan="2">Master’s Degree</td><td>Doctorate Degree</td></tr>
<tr><td colspan="2">4. Subject specialisation</td><td>Geography only</td><td colspan="2">Geography in Education</td><td>Others (specify):</td></tr>
<tr><td colspan="2">5. No. of years in teaching</td><td>Less than 5 years</td><td colspan="2">6-10 years</td><td>More than 10 years</td></tr>
<tr><td colspan="2">6. The Grade you mostly teach (Choose one only)</td><td>10</td><td colspan="2">11</td><td>12</td></tr>
<tr><td colspan="2">7. Number of learners that you teach Geography</td><td colspan="2">Fewer than 50</td><td colspan="2">More than 50</td></tr>
<tr><td colspan="3">8a. Have you taught lessons on climate change in the last year?</td><td colspan="2">Yes</td><td>No</td></tr>
<tr><td rowspan="4">b. If your answer to 8a is ‘Yes’, answer sub items i and ii (Choose one in each case).</td><td rowspan="2">i) Where do you mainly get information on climate change content and concepts?</td><td>Television</td><td>Radio</td><td>Internet</td><td>Newspaper</td></tr>
<tr><td>School textbooks</td><td colspan="2">Workshops/seminars</td><td>Peers/Subject Advisor</td></tr>
<tr><td rowspan="2">ii) Where do you mainly get information on methods of teaching climate change?</td><td>Television</td><td>Radio</td><td>Internet</td><td>Newspaper</td></tr>
<tr><td>School textbooks</td><td colspan="2">Workshop/seminar</td><td>Peers/Subject Advisor</td></tr>
</table>

Figure 12: Teacher details

With Section A sorted out, the next issue that was dealt with was the layout of the items.

The layout of the items was also revised. In the pilot draft, boxes were provided at the extreme right-hand corner to the options for respondents to write in the letter that bore the most correct answer. In the revised version, boxes were provided in front of the letters bearing the options. The new format looks far simpler, as it saves the reader energy and time transiting from the question to the box to write the answer and back again. The revised format gives the reader time to focus on the questions. An example of how to key in the correct answer was also provided, and it read:

The instrument for measuring atmospheric temperature is a

- ☐ A. Thermometer
- ☐ B. Spectrometer
- ☐ C. Barometer
- ☐ D. Hygrometer

Providing an example also helps to reduce anxiety and minimise the chances of making mistakes. It may also reduce item non-response. In general, the provision of an example is a strategy to increase the response rate. The next step taken was item selection.

3.2.3.2.12 Translation of the Questionnaire

One of the measures taken in the development of the questionnaire to ensure valid conclusions was the translation of the questionnaire into Afrikaans. Translation of a questionnaire into another language enables fielding it in the language required. The translation of a questionnaire is a way of accommodating different linguistic populations. It is an attempt to implement equivalent instruments in cross-national and cross-lingual survey research (Harkness and Schoua-Glusberg, 1998:87).

The Western Cape is a culturally diverse area. It is a melting pot of different languages, with English and Afrikaans being the most widely spoken languages in the province. For some teachers in the Western Cape, Afrikaans is their first language and the language of instruction in schools. A context like the Western Cape necessitates that everyone is treated with dignity and respect, which is an axiological requirement of responsible judgment in research. However, translating scientific terminologies/technical terms, names and idioms poses lexical, conceptual and stylistic problems (Sharkas, 2009; Sarukkai, 2001). This suggests that translating some concepts, names and terminologies associated with climate change from English to Afrikaans could be problematic. The researcher addressed this problem by ensuring that the translation was done by an academic who was an expert in Geography and proficient in English and Afrikaans (see English and Afrikaans versions of the Questionnaire in Appendix 7 and 8, respectively).

The process of questionnaire development was concluded with the production of a questionnaire that contained valid items on climate change science and climate change pedagogy. Besides validity concerns, survey research is also concerned with questions about the reliability of the measurement. Details of measurement reliability are discussed in Section 3.2.3.3 in this chapter. The next action taken to ensure instrument validity was the production of a finalised item-specification table.

3.2.3.2.13 Finalised Item Specification Table

Table 24: Specification table for climate change science Items

Item No	Content topics	Cognitive level of items			Key	Code
		Factual 1	Conceptual 2	Procedural 3		
1	Composition of the atmosphere	X			C	1
2	Concept of global warming	X			D	1
3	Anthropogenic of climate change		X		D	2
4	CO_2 emissions and future climates		X		B	2
5	Climate science and uncertainty		X		B	2
6	Evidence of global warming		X		A	2
7	Climate change and drought			X	C	3
8	Vulnerability of sub-Saharan Africa		X		B	2
9	Climate change and development		X		C	2
10	Differential effects of global warming in Northern and Southern Hemispheres		X		B	2
11	Carbon sequestration	X			B	1
12	Rural people adaptation to climate change			X	B	3
13	Hindrance to implementation of climate change policies			X	A	3
14	Options for developing countries if global warming continues for centuries			X	C	3
15	South Africa and global climate change initiative	X			B	1
TOTAL		**4**	**7**	**4**	**15**	**30**

Table 24 shows that there were five questions from each subdomain of climate change science, giving a total of 15 questions that measure literacy in climate change science. The distribution of the items in terms of cognition level is as follows:

- Factual items = 4
- Conceptual items = 7
- Procedural items = 4

Content topics 1 to 5 focus on climatic processes and probable causes of climate change; 6 to 10 focus on climate change impacts; and 11 to 15 focus on climate change responses.

Table 25: Specification table for Climate Change Pedagogy Items

Item No.	Content topic	Cognition level of items			Key	Code
		Factual 1	Conceptual 2	Procedural 3		
1	Children and climate change		X		**B**	**2**
2	Aim of climate change education	X			**D**	**1**
3	Link between society, resources and development		X		**A**	**2**
4	Competence for vulnerability analysis			X	**C**	**1**
5	Decision making and adaptation to climate change			X	**D**	**2**
6	Cognitive dissonance and learning		X		**D**	**2**
7	Facilitating formulation of ideas			X	**C**	**3**
	Concept of transfer of knowledge			X	**D**	**3**
9	Overcoming students misconceptions			X	**C**	**3**
10	Formative assessment and learning			X	**D**	**3**
TOTAL		**1**	**3**	**6**	**10**	**22**

Table 25 shows that there were five questions in each subdomain. In all, there were 10 questions for assessment of climate change pedagogical literacy. The distribution of the items in terms of cognition level is as follows:

- Factual items = 1
- Conceptual items = 3
- Procedural items = 6

Content topics 1 to 5 focus on aims and significance of climate change education, and 6 to 10 focus on constructivist teaching principles.

Having explained all the steps that were taken to ensure that the measurement instrument was valid, the next step is to discuss issues relating to measurement validity as they applied in this study.

3.2.4 Steps Taken to Achieve Measurement Reliability

Measurement reliability is concerned with the ability of an instrument to measure consistently. For an instrument to produce consistent results it must be dependable (Tavakol, Mohagheghi and Dennick, 2008). One of the ways a researcher can enhance the dependability of a measurement instrument is through piloting; hence De Vaus (1993:54) cautions: "Do not take the risk; pilot test first." In this study, piloting served mainly for achieving validity rather than reliability.

Actions and considerations to achieve measurement reliability in this study were carried out in two ways: reducing measurement error, and achieving a high internal consistency of the items. Details of these actions are discussed below.

3.2.4.1 Measurement Error

Measurement error occurs when a difference exists between observable and unobservable variables, that is, the difference existing between observable and unobservable variables, and this difference is due to sampling error, coverage error, and non-response error (Lavrakas, 2008). In this study, measurement was determined in terms of sampling error and non-response. Sampling error, Patten (2009) explains, is error created by random sampling, usually measured in terms of standard error for a particular statistic, and in terms of mean is the square root of the variance. The logic of sampling error is that the quality of a sample affects the quality of the conclusion drawn from a sample to the population. Simply put, a poor sample could lead to an improper conclusion.

Sampling error in this study was based on two criteria: representativeness of the sample and standard error of mean. The idea of estimating sampling error in this study was based on the assumption that a good sampling design should yield a representative sample. Technically, a research instrument is said to be reliable to the degree it has measurement error. For the fact that reliability is an estimate of the amount of measurement error in a test, the interpretation of reliability is the correlation of a test with itself. Squaring this correlation and subtracting from 1.00 gives an indication of the measurement error (Tavakol and Dennick, 2011).

One of the factors associated with measurement error in a study is the rate of response from the participants. Gallagher (2004) identifies two main kinds of non-response in survey research, namely: unit non-response (when a subject does not complete the survey instrument), and item non-response (when a respondent fails to answer one or more of the questions posed). Lavrakas (2004) attributes non-response to non-contacts, refusals and language barriers. The level of non-response error committed in a study is obtained by calculating the error due to unit non-response and error due to item non-response respectively. The researcher calculated the unit non-response by calculating the number of the respondents who did not complete the survey. This is obtained by subtracting the number of participants who responded to the questionnaires from the total number of participants who were selected for the study.

One of the steps taken to reduce measurement error was selecting a large sample that was representative of the population, so that the results of the analysis of the data collected from the sample can be generalised to the larger population. The next step was calculating the level of confidence in the conclusions. Steps were also taken to achieve a high response rate by:

- Making the questionnaire attractive in terms of its format

- Providing clear instructions so that the participants would be able to read the instructions and understand what they were required to do
- Ensuring that the questionnaire was not lengthy and boring
- Ensuring that the questions were constructed in simple language so that the participants would not struggle with understanding the questions
- Allowing the participants sufficient time to complete the questionnaire, but not to complete it at home or anywhere else of their choosing, and
- Translating the questionnaire into languages spoken and written by the participants.

Other measures targeting a high response rate include obtaining approval for access from the participants' employers, securing informed consent from the participants, and clearly explaining the purpose of the study and the benefit of participation in it to the participants. Most of these measures were addressed during sample selection, addressing the ethical issues, and during the development of the instrument (see sections 3.2.1, 3.2.2 and 3.2.3 of this chapter).

3.2.4.2 Internal Consistency of the Instrument

Another important consideration in this study was ensuring that the items in the instrument were consistent with each other. Fan and Sun (2013) outline different ways of estimating the internal consistency of a measurement instrument. These include Cronbach's coefficient α (coefficient of internal consistency), inter-rater reliability coefficient (i.e. coefficient of stability), and alternate-form reliability coefficient (i.e. coefficient of equivalence). These forms of reliability estimates are not conceptually equivalent for the reason that they capture the measurement error from different sources. For the computation of internal consistency, particularly with Cronbach's coefficient alpha and alternatives, the main source of measurement error is content sampling. For the coefficient of stability, the main source of measurement error is time sampling. The main source of measurement error when the focus is on coefficient of equivalence is content sampling across forms, whereas for inter-rater reliability the main source of measurement error is rater inconsistency (e.g. inconsistent rating criterion for different ratees). The type of reliability coefficient a researcher employs in a specific situation depends on what measurement error source is the most relevant concern in that situation.

For the present study, the reliability of the instrument was determined on the basis of the internal consistency of the scores that it produced, which Tavakol and Dennick (2011) describe as the extent to which all the items in a test measure the same concept or construct. Chen and Krauss (2004) describe the internal consistency of an instrument as an estimate of the consistency of the responses to items or a subset of items on a measure. Bear in mind that the questionnaire developed in Section 3.2.3 contains a section measuring climate change science literacy and a section measuring climate change pedagogical literacy. Each section of the questionnaire consists of a number of parts. The section measuring climate change science literacy consists of three parts: climatic processes and probable causes of climate change, climate change impacts and climate change responses, whereas the section measuring climate change pedagogical literacy consists of two parts: the aims and significance of climate change education, and constructivist teaching principles and practice. Internal consistency is an estimate of the uniformity of the responses to the items or to a part of the instrument. All estimates of measurement reliability are based on the data collected in the full-scale data collection phase of this study. Details of the full-scale data collection are discussed in the next section.

3.2.5 Full-scale Data Collection

A retrospection of the rigors associated with piloting, particularly obtaining the desired sample size, provided an insight into the challenges the researcher would face during full-scale data collection. At this point it became very clear to the researcher that the process of data collection would not be as easy as articulated in the research proposal. First, the application of No-rule sampling suggests that the participants would be the individuals that the researcher could find and were willing to participate in the study. At this point the researcher, with the help of the supervisors, contacted the eight Education District Curriculum Advisors for Geography in the province telephonically, requesting their support and help in creating an opportunity to administer the questionnaire at the venues of their district meetings and workshops. All the Curriculum Advisors responded positively to the request: the questionnaires were administered at the workshop venues. The participant gave their consent to participate in the study by completing and signing the consent forms. The participants chose their language by choosing the version of the questionnaire to compete - English or Afrikaans (see Appendices 7 and 8).

3.2.6 Techniques for Data Analyses

At the end of the administration of the questions, the researcher marked the completed multiple-choice questionnaire using the test blueprint to obtain the respondents' scores on each section of the test. The collected data was mainly numerical. An identification number was generated for each respondent to facilitate data capture and data organisation. Data was entered into the spreadsheet according to its origin. Background details were captured first, followed by data on CCS, then data on CCP. All data was organised in accordance with the sub-variables of the study (see Appendices 9, 10, and 11).

Data analysis may take two forms – simple descriptive statistics and more sophisticated statistical inference. The type of statistical techniques employed at any given time depends on the purpose for which collected data serves. Sections 1.5 highlights the purpose of this study and the objectives it sought to achieve, through statistical analysis of observational data, as follows:

a) Describe the representativeness of the sample to the population;
b) Describe the response rate of the study;
c) Describe the level of climate change science literacy of the respondents;
d) Describe the level of climate change pedagogical literacy of the respondents;
e) Statistically determine the influence of gender, age, qualification, specialisation, experience, grade mostly taught, their experience in providing instruction on

climate change and the location of their school on the climate change science literacy of the respondents;

f) Statistically determine the influence of gender, age, qualification, specialisation, experience, grade mostly taught, their experience in providing instruction on climate change and the location of their school on climate change pedagogical literacy of the respondents;
g) Calculate the reliability of the instrument measuring climate change science literacy;
h) Calculate the reliability of the instrument measuring climate change pedagogical literacy; and
i) Calculate the correlation between observations of climate change science literacy and observations of climate change pedagogical literacy.

These objectives require different statistical operations, including percentage frequency, the Mann-Whittney U test, the Kruskal-Wallis test, the Cronbach's alpha test, the Guttman's split-half test and Spearman's test. Details of the application of these statistical analysis techniques in achieving the afore-stated objectives are explained below.

3.2.6.1 Percentage Frequency

Percentage is a number or ratio expressed as a fraction of 100. In this study, percentage was used to calculate sample representativeness – a measure of the extent to which a small sample that was tested from a larger group was similar to the larger group (representative of the group). If the sample is representative, it can be assumed that the range of scores from the sample would be very similar to the larger group if they had also been tested. Frequency, on the other hand, is the number of occurrences of a repeating event. Percentage frequency is concerned with determining the number of times a particular event or behaviour occurred in a sample expressed in percentage. The number is determined by the number of occurrence of each item in the category. The frequency distribution table is an arrangement of the values that one or more variables take in a sample. Frequency distribution tables often present three important details: the category, the count and the percentage. Decisions were based on the count and % (Carlson and Winquist, 2014; Stangor, 2011).

The following operations were conducted with percentage frequency:

a) Describing the representativeness of the sample to the population;
b) Describing the response rate of the study;
c) Describing the level of climate change science literacy of the respondents; and
d) Describing the level of climate change pedagogical literacy of the respondents.

The results of these operations are displayed in tables and bar graphs, and are used to determine the extent to which objectives f), g), h) and i) stated in section 1.5 of Chapter 1 were attained.

3.2.6.2 Mann-Whittney U test

The Mann-Whitney test, also referred to as the Wilcoxon rank sum test, is a nonparametric test that compares two unpaired groups. The Mann-Whittney U test is used to determine whether two independent samples come from the same distribution. In other words, it is used to determine whether two independent groups are homogeneous. Application of the Mann-Whitney test requires that measurement and sampling errors are minimal, that there is independence within groups and mutual independence between groups, and that the data is ordinal. It does not require the assumption that the differences between the two samples are normally distributed. The aim is to determine if there is a significant difference between the two comparison groups. When the sample size is greater than approximately 30, the Mann-Whitney U statistic follows the z distribution. If z is less than -1.96, or greater than 1.96, the null hypothesis is rejected. The decision is taken with alpha at 0.05 (Nachar, 2008; Sheskin, 2007). For the purpose of this study, the Mann-Whitney test was used to test observed variation in the categories of gender, age, teaching experience and experience in climate change science literacy and climate change pedagogical literacy.

3.2.6.3 Kruskal-Wallis Test

The Kruskal-Wallis test is applied where there is one continuous dependent variable and more than two comparison groups or independent samples. The Kruskal-Wallis test is used to verify whether there is a significant difference between the various comparison groups. Like the Mann-Whitney test, the Kruskal-Wallis test holds that responses are ordinal and does not function with the assumption that all populations under comparison are normally distributed (Corder and Foreman, 2009). The Kruskal-Wallis test was employed in this study to determine if statistical differences in the location of the school, qualification, specialisation and grade mostly taught account for variations in climate change science literacy and climate change pedagogical literacy.

Results of the Mann-Whitney test and the Kruskal-Wallis test are displayed in tables and used to determine how far objectives j) and k) in section 1.5 were been attained.

3.2.6.4 Cronbach’s Alpha Test

Cronbach's alpha test is used for determining the internal consistency or average correlation of items in a survey instrument to gauge its reliability. The assumption of this test is that the scores are obtained from a single measurement; that is once. The value of alpha is expresses as a number between 0 and 1. Alphas are increased if the items in the test are correlated. High alpha does not always mean high internal consistency. This is because the internal consistency of a test is a function of the length of the test: short tests often produce low alphas. Too high a value of alpha could also be an indication that some items in the test are of little or no use in the scale. An alpha value of 0.60 is average reliability and an alpha value of 0.70 and above is regarded as high reliability (Maiyaki and Mokhtar, 2011; Sekaran and Bougie, 2010), and an alpha value of less than 0.6 is regarded as unsatisfactory (Malhotra, 2004). For the purpose of this study, alpha values exceeding 0.6 were an acceptable reliability.

3.2.6.5 Guttman's Split-half Test

The estimate of reliability using Guttman's test is based on correlating the results of the two halves of the same test. This analysis assumes that there is only one administration of the test. The items of the two halves should match in terms of content and difficulty. Guttman's split-half test does not require equal variances between the two split forms. The best split will be that in which each half contains highly inter-correlated items. A lenient cut-off for exploratory research is 0.6. Values from 0.7 and higher are desirable. The results of the Cronbach's alpha test and the Guttman's split-half test were presented in tables and used to determine the extent to which objectives l) and L), stated in section 1.5, were attained.

3.2.6.6 Spearman Test of Correlation

The Spearman test of correlation is a form of rank order statistical analysis, calculated with the same formula as for Pearson's r correlation but using rank rather than interval data. The minimum acceptable value for rho is 0.6. This test was used to determine the correlation between observations of climate change science literacy and observations of climate change pedagogical literacy. The results of the analysis are presented in a scatterplot and were used to determine the extent to which objective m) stated in section 1.5 was attained.

3.3 SUMMARY OF THE CHAPTER

In this chapter, an attempt was made to describe the methodological choices and procedures for the assessment of climate change science literacy and climate change pedagogical literacy of geography teachers in the Western Cape, including justifications for these methods and procedures. Two kinds of variables were identified: categorical independent variables (variables relating to school and teacher characteristics, such as location of school, age, gender, qualifications, specialisation, experience, grade mostly taught, and experience in providing instruction on climate change) and dependent variables (literacy in climate change and literacy in climate change pedagogy, including their sub-variables). The former yield categorical data, while the latter yield continuous data. The unit of analysis was geography teachers in the Western Cape. In the light of the purpose of the study and the kind of data the variables are expected to produce, this survey took the descriptive, explanatory, quantitative design, which is situated within the positivist paradigm. To collect the data for answering the research questions and testing the hypotheses, a criterion reference multiple-choice questionnaire was constructed.

A survey research project situated within the positivist paradigm puts emphasis on measurement validity and measurement reliability. Measurement validity is concerned with the extent to which the elements included in the questionnaire are the suitable characteristics the study was designed to measure, whereas measurement reliability is concerned with score consistency. To achieve measurement validity in this study, the items of the questionnaire were developed with reference to the conceptual framework on climate change literacy and climate change pedagogical literacy. The initial draft of the questionnaire was piloted with 15 geography teachers. Item analysis and item sampling were conducted to ensure that only valid items were included in the questionnaire for the full-scale data collection.

A sample of 194 geography teachers was selected with the ‘No Rule’ sampling technique. The choice of the ‘No Rule’ sampling was motivated by two main considerations. First, a survey research requires a large sample that is representative of the population, but the absence of a comprehensive list of geography teachers in the province made it impracticable to select a large sample randomly. Secondly, ethics bestows a right on individuals to voluntarily decide whether or not to participate in a research project, which also did not permit the selection of participants randomly. The participants completed the questionnaire during their workshops. The collected continuous data on the dependent variables (literacy in climate change science and literacy in climate change pedagogy) were analysed with percentage frequency to determine the geography teachers’ level of literacy in climate change science and their level of literacy in climate change pedagogy.

The collected categorical data on the independent variables was analysed with the Mann-Whitney test for variables that occurred in two categories, and the Kruskal-Wallis test for variables that occurred in more than two categories. Internal consistency of the scores was tested with the Cronbach's alpha test and Guttman's split-half test, targeting a coefficient alpha of at least 0.6. The extent to which the scores for literacy in climate change and scores on literacy in climate change pedagogy correlated was estimated with Spearman's test. Results of these statistical analyses are presented in tables and graphs in the next chapter.

CHAPTER 4

THE RESULTS

This chapter presents the results of the analyses and interprets the data collected from the 194 participants in the study using the questionnaire that required information about the teacher and the school as well as contained questions to assess teachers' climate change science literacy and climate change pedagogical literacy. The chapter is organised into the following sections: the demographics of the respondents, sample representativeness, response rate, instrument reliability, the respondents' level of climate change science literacy and the respondents' scores on climate change pedagogical literacy. The chapter concludes with a summary of the results.

4.1 THE DEMOGRAPHIC OF THE RESPONDENTS

There are two aspects of demographic details of the participants included in this study: school details and teacher details. Data collected on these two aspects are presented below.

4.1.1 School Details

- Districts where school is located
- School location
- School type
- Learner population
- Teacher population
- Population of Geography teachers

4.1.1.1 Districts Where Schools Are Located

Table 26: Frequency table showing respondents by district

Category	Count	Per cent
Metropole North	24	12.37
Metropole South	42	26.65
Metropole East	44	26.68
Metropole Central	39	20.1
Cape Winelands	9	4.64
West Coast	6	3.09
Eden-Karoo	22	11.34
Overberg	8	4.12
NR	0	0
TOTAL	**194**	**100**

The data presented in Table 26 show that the highest number of respondents (44) came from Metro East. Metro South and Metro Central had 42 and 39 respondents respectively. The remaining five districts contributed less than 50% of the respondents. West Coast had the fewest number of respondents, with six. In this education district the curriculum advisor indicated that there would be no formal meetings apart from school visits during the time of data collection. The figures indicate that more than 50% of the respondents who participated in the study came from Metropole East, Metropole South and Metropole Central. The rest of the respondents came from the five other education districts. This result suggests that the majority of Geography teachers that took part in the study taught in schools situated in predominantly urban districts.

4.1.1.2 School Location

Table 27: Frequency table showing respondents by school location

Category	Count	Per cent
Rural	21	10.82
Urban	139	71.65
Semi urban	34	17.53
NR	0	0
TOTAL	**194**	**100**

The data presented in Table 27 show that, of the 194 respondents who participated in this study, 139 came from schools in urban areas, 34 from schools in semi-urban areas, and 21 from schools in rural areas. These figures show that over 70% of the respondents came from schools in urban areas. This distribution reflects the general ratio of school per type of location that offers FET Geography in the province.

4.1.1.3 School Type

Table 28: Frequency table showing respondents by school type

Category	Count	Per cent
Mixed	186	95.88
Boys only	6	3.09
Girls only	2	1.03
NR	0	0
TOTAL	**194**	**100**

Table 28 shows that 186 out of the 194 respondents, representing about 96% of the sample, came from mixed schools. Schools for only girls or boys contributed 3.09% and 1.03% of the sample respectively. The majority of the respondents (95.88%) came from mixed schools. This distribution shows that the majority of high schools in the Province are mixed.

4.1.1.4 Learner Population

Table 29: Frequency table showing respondents by number of learners

Category	Count	Per cent
<1000	88	45.36
>1000	106	54.64
NR	0	0
TOTAL	**194**	**100**

The data presented in Table 29 show that 106 out of the 194 respondents, representing 54.64%, came from schools that had more than 1 000 learners, while 88 teachers, representing 45.36%, came from schools with less than 1 000 learners. It could be inferred from the data that the majority (54.64%) of the respondents came from schools that have more than 1 000 learners. This result suggests that the majority of high schools in the Province have over a thousand learners.

4.1.1.5 Teacher Population

Table 30: Frequency table showing respondents by teacher population

Category	Count	Per cent
<30	72	37.11
>30	122	62.89
NR	0	0
TOTAL	**194**	**100**

The data in Table 30 shows that, of the 194 respondents, 72, representing 37.11%, came from schools with a population of less than 30 teachers. On the other hand, 122 of the respondents, representing 62.89%, came from schools with a teacher population of over 30. On the basis of the data in Table 30, the majority (62.89%) of the respondents in this study came from schools with more than 30 teachers. This result shows the general pattern in the distribution of Geography teachers in the Province, with most schools having more than thirty teachers.

4.1.1.6 Population of FET Geography Teachers

Table 31: Frequency table showing participants by population of FET Geography Teachers

Category	Count	Per cent
2	89	45.88
1	32	16.49
>2	73	37.63
NR	0	0
TOTAL	**194**	**100**

The data presented on Table 31 show that 89 out of the 194 respondents, representing 45.88%, came from schools with two geography teachers; 73 of the respondents, representing 37.63%, came from schools with more than two geography teachers; and 32 of them, representing 16.5%, came from schools with one geography teacher. With the data shown it can be concluded that the majority (45.88%) of the respondents came from schools that have two FET Geography teachers.

4.1.2 Teacher Details

- Data collected on the following teacher details are presented in this section:
- Gender
- Age
- Qualification
- Specialisation
- Teaching experience
- Grade mostly taught
- No of learners taught Geography
- Experience in providing instruction in climate change
- Main sources of information on climate change science
- Main sources of information on climate change pedagogy

4.1.2.1 Gender

Table 32: Frequency table showing participants by gender

Category	Count	Per cent
Female	87	44.85
Male	107	55.15
NR	0	0
TOTAL	**194**	**100**

The data in Table 32 show that 107 of the respondents (55.16%) were men and 87 (44.85%) were women. These figures suggest that there was a narrow difference in the distribution of the respondents in relation to gender, with slightly more males, which could be influenced by the fact that teachers sometimes have to travel long distances to workshops.

4.1.2.2 Age

Table 33: Frequency table showing participants by age

Category	Count	Per cent
<40	38	19.59
>40	155	79.9
NR	1	0.52
TOTAL	**194**	**100**

The data in Table 33 show that one of the respondents did not provide any information pertaining to his or her age. Of the 193 respondents who provided information about their age, 38 (19.59%) were younger than forty years of age, whereas 155 (79.9%) were older than 40 years. These figures suggest that the majority of the participants in the study were over 40 years of age.

4.1.2.3 Qualification

Table 34: Frequency table showing participants by qualification

Category	Count	Per cent
Masters	8	4.12
Postgraduate Diploma	37	19.07
Honours	53	27.32
Bachelor	66	34.02
Ordinary Diploma	29	14.95
NR	1	0.52
TOTAL	**194**	**100**

The data in Table 34 shows 53 respondents with Honours degrees, 37 with a postgraduate diploma, 29 with ordinary diplomas, and eight with a master's degree. One of the respondents did not provide details of his or her highest qualifications. The distribution of qualifications suggests that the majority of the respondents 66, (34.02%), had Bachelor's degrees.

4.1.2.4 Specialisation

Table 35: Frequency table showing participants by specialisation

Category	Count	Per cent
Geography and Education	83	42.78
Geography only	85	43.81
Geography and another subject	5	2.58
Other subjects	20	10.31
NR	1	0.52
TOTAL	**194**	**100**

The data in Table 35 show that 83 (42.78%) respondents specialised in Geography and Education, 85 (43.81%) specialised in Geography only, five (2.58%) had studied Geography combined with another subject, and 20 (10.31%) studied other subjects that are not geography. One of the respondents did not provide details of his or her specialisation. The study concludes that the majority 85 (43.81%) of respondents studied Geography only. This result is a reflection the situation in basic education where teachers teach subjects they did not specialise in.

4.1.2.5 Teaching Experience

Table 36: Frequency table showing participants by years in teaching

Category	Count	Per cent
>10	158	81.44
<10	35	18.04
NR	1	0.52
TOTAL	**194**	**100**

The data in Table 36 show that 158 out of a total of 194 respondents had been teaching for more than ten years, and 35 of them had been in teaching for less than ten years. One respondent did not provide any details of his or her experience in teaching. Based on the data shown, the majority (81.44%) of the respondents had been in teaching for more than ten years. This result suggests that there are more experienced than in experienced Geography teachers that participated in the study.

4.1.2.6 Grade Mostly Taught

Table 37: Frequency table showing participants by Grade mostly taught

Category	Count	Per cent
10	52	26.8
11	30	15.46
12	112	57.73
NR	0	0
TOTAL	**194**	**100**

The data in Table 37 show that 52 respondents mainly taught Grade 10, 30 of them mainly taught Grade 11, and 12 respondents mainly taught Grade 12. The study concludes that the majority (57.73%) of the respondents taught mainly Grade 12. This results suggests that the majority of teachers that attend professional development meetings are Grade 12 Geography teachers.

4.1.2.7 Number of Learners Taught Geography

Table 38: Frequency table showing participants by number of leaners taught geography

Category	Count	Per cent
>50	149	76.8
<50	45	23.2
NR	0	0
TOTAL	**194**	**100**

Table 38 shows that 149 respondents had more than 50 Geography learners in their classes, whereas 45 respondents had fewer than fifty Geography learners in their classes. The study therefore concludes that the majority (76.80%) of the respondents taught Geography to more than 50 learners. This result suggests that more than fifty learners attend a Geography lesson at any given time.

4.1.2.8 Experience in Providing Instruction on Climate Change

Table 39: Frequency table showing participants by experience in providing instruction on climate change

Category	Count	Per cent
Yes	183	94.33
No	11	5.67
NR	0	0
TOTAL	**194**	**100**

The data in Table 39 show that 183 respondents had taught lessons on climate change in the previous year, whereas 11 of the total had not taught lessons on climate change in the previous year. The study concludes that the majority (94.33%) of the respondents had taught lessons on climate change in the previous year. This result suggests that climate change concepts are taught in schools in the Province.

4.1.2.9 Main Sources of Information on Climate Change Science

Table 40: Frequency table showing participants by their main sources of information on climate change science

Category	Count	Per cent
Workshop/seminar	4	2.06
School textbooks	75	38.66
Internet	79	40.72
Newspapers	16	8.25
Television	6	3.09
Peers and Subject Advisors	1	0.52
Radio	2	1.03
NR	11	5.67
TOTAL	**194**	**100**

Table 40 shows that 2.06% of the respondents got the information they teach on climate change from workshops and seminars, 38.66% got theirs from school textbooks, 40.72% got theirs from the Internet, 8.25% got theirs from newspapers, and 3.09% got their information from television. The respondents who got their information from peers and subject advisors made up 0.52% of the respondents, and those who got theirs from the radio made up 1.03% of the respondents. The study concludes that the majority (40.72%) of the respondents got the information on climate change science from the Internet. These figures suggest that most of the respondents got information on climate change science from electronic media rather than from human resources such as peers, subject advisors, workshops and seminars. This result suggests that Geography teachers obtain information on climate change concepts from a variety of sources.

4.1.2.10 Main Sources of Information on Climate Change Pedagogy

Table 41 Frequency table showing participants by their main sources of information on climate change pedagogy

Category	Count	Per cent
Workshop/seminar	49	25.26
School textbooks	86	44.33
Internet	28	14.43
Newspapers	0	0
Television	1	0.52
Peers and Subject Advisors	19	9.79
NR	11	5.67
TOTAL	**194**	**100**

The data in Table 41 shows that the respondents get information on climate change pedagogy from different sources, with 9.79% getting information from their peers and subject advisors, 14.43% from the Internet, 44.33% from school textbooks, 25.26% from workshops and seminars, and 0.52% from television. A total of 11 respondents, representing 5.67%, did not indicate their sources of information on the methods of teaching climate change. Based on these figures, it is concluded that the majority (44.33%) of the respondents got information on climate change pedagogy from school textbooks. This result suggests that Geography teachers obtain information on methods of facilitating lessons on climate change from a variety of sources, mainly from schools textbooks, workshops and seminars.

4.2 SAMPLE REPRESENTATIVENESS

Table 42: Sample percentage representation

Category	Population	Sample	Difference	% Difference
Metropole North	56	24	32	42.86
Metropole South	69	42	27	60.87
Metropole East	63	44	19	69.84
Metropole Central	56	39	17	69.64
Cape Winelands	70	9	61	12.86
West Coast	26	6	20	23.08
Eden-Karoo	47	22	25	46.81
Overberg	21	8	13	38.1
TOTAL	**408**	**194**	**214**	**47.55**

Table 42 shows that the population of FET band geography teachers in the Western Cape at the time of data collection (based on figures supplied by curriculum advisors from the various districts) was 408. Of this number, 194 (47.55%) participated in the study. A total of 214 FET Geography teachers did not take part in this study. These figures suggest that the sample for this study represented 47.55% of all FET Geography teachers in the Western Cape.

4.3 ITEM RESPONSE RATE

Table 43: Item response rates

Item	Sample Size	No. of Responses	Response Rate	Non-response	Non-response Rate
District where school is situated	194	194	100		0
School Location Type	194	194	100	0	0
School Type	194	194	100	0	0
Approximate No. of Learners	194	194	100	0	0
No. of Teachers	194	194	100	0	0
No. of FET Geog. Teachers	194	194	100	0	0
Gender	194	194	100	0	0
Age	194	193	99.49	1	0.52
Highest Qualification	194	193	99.49	1	0.52
Specialisation	194	193	99.49	1	0.52
Teaching experience	194	193	99.49	1	0.52
Grade mostly taught	194	194	100	0	0
Number of geography learners	194	194	100	0	0
Experience in providing instruction on climate change	194	194	100	0	0
Sources of information on climate change science	194	183	94.33	11	5.67
Sources of information on methods of teaching lessons on climate change	194	183	94.33	11	5.67

The data in Table 43 shows zero non-response rates on 10 out of 16 items of background information. The items with zero non-response rates include district where school is situated, school location type, school type, approximate number of learners, number of teachers, number of FET Geography teachers, gender, age range, grade mostly taught, number of learners taught geography, and if teacher has taught geography in the past year. With the exception of sources of information on climate change and sources of information on methods of teaching climate change lessons, which have non-response rates of 5.67 each, the rest of the items have nonresponse rates of 0.52 each. Based on the information in Table 43, low item non-response was encountered in this survey.

4.4 RESULTS OF TEST OF INSTRUMENT RELIABILITY

4.4.1 Reliability of the Climate Change Science Literacy Questionnaire

4.4.1.1 Confidence Interval and Standard Error of Mean of Climate Change Science Literacy

Table 44: Mean and confidence interval for climate change science

Variable	Valid N	Mean	Confidence Interval		Median	Min	Max	SDev	SEM
			-95%	95%					
Climatic Processes and causes of Climate Change	194	5.24	5.02	5.45	5	1	8	1.52	0.11
Climate Change Impacts	194	6.27	5.92	6.62	7	0	11	2.49	0.18
Climate Change Responses	194	7.29	6.85	7.73	7	0	13	3.13	0.36
CCS	**194**	**18.79**	**18.09**	**19.5**	**20**	**3**	**29**	**5**	**0.25**

The data in Table 44 show that the observed mean score for 194 FET Geography teachers in the entire assessment was 18.79, which is situated between the -95% and 95% confidence level, as indicated by their respective means of 18.09 and 19.5. A median score of 20 entails that 20 is the middle score if all the scores for the 194 participants are lined up from the least to the highest. The lowest score on climate change impacts and climate change solutions was zero, whereas the lowest score on climate processes and causes of climate change was 1. The widest gap between the minimum and the maximum score was 13, which was obtained on climate change responses. The standard deviation scores show that climate change responses scores are more dispersed from the mean that the scores on climatic processes and causes of climate change and climate change impacts. Standard error of mean for the three variables was 0.11, 0.18 and 0.36 respectively, and 0.25 for the CCS. Therefore, the study concludes that the mean scores in the entire assessment on CCSL lie between the -95% and 95% confidence intervals, with a standard error of mean of 0.25.

4.4.1.2 Internal Consistency of the Items Measuring Climate Change Science Literacy

Table 45: Results of Cronbach's test of internal consistency of CCSLQ items

Variable	Mean if detected	Variance if deleted	Item total Correlation	Alpha if deleted
CCS-Q1-Factual-C-1	8.15	2.43	0.37	0.61
CCS-Q2-Factual-D-1	7.7	2.45	0.22	0.62
CCS-Q3-Conceptual-D-2	7.72	2.54	-0.06	0.66
CCS-Q4-Conceptual-B-2	7.72	2.39	0.38	0.6
CCS-Q5-Conceptual-B-2	8.14.	2.36	0.27	0.62
CCS-Q6-Conceptual-A-2	7.74	2.39	0.34	0.61
CCS-Q7-Procedural-C-3	8	2.34	0.33	0.61
CCS-Q8-Conceptual-B-2	7.82	2.29	0.51	0.58
CCS-Q9-Conceptual-C-2	8.5	2.51	0.05	0.64
CCS-Q10-Conceptual-B-2	7.98	2.36	0.31	0.61
CCS-Q11-Factual-B-1	8.26	2.39	0.25	0.62
CCS-Q12-Procedural-B-3	8.24	2.41	0.19	0.63
CCS-Q13-Proceudral-A-3	7.78	2.31	0.52	0.58
CCS-Q14-Procedural-C-3	7.99	2.45	0.09	0.65
CCS-Q15-Procedural-B-3	7.97	2.41	0.17	0.64
		TOTAL	**0.12**	**0.64**

Table 45 shows that, with the exception of Q3, all the items in CCSLQ have a positive total item correlation, even though their values vary. Q3 has a -0.06 item total correlation and, if this item was deleted from the questionnaire, the alpha would increase from 0.64 to 0.66. Similarly, Q14 has an item total correlation of 0.09 and an alpha value of 0.65. If Q14 was deleted from the questionnaire it would increase the alpha from 0.64 to 0.65. Deleting any other item from the instrument would lead to a reduction in the total alpha to 0.64. Q8 has a 0.51 item total correlation and an alpha value of 0.58 and, if deleted from the scale, would lead to a reduction in calculated alpha from 0.64 to 0.58. Thus, Q8 is viable. In the light of the data presented, the CCSLQ has an item total correlation of 0.12 and an alpha value of 0.64.

Table 46: Results of Guttman's split-half test of reliability of CCSLQ items

N=194	Summary of 1ST Half	Summary of 2ndHalf	Corr. of 1st and 2nd Half	Guttman's Split Half Reliability
No. of items	8	7	0.59	0.74
Mean	3.75	3.85		
Sum	724	940		
Std. Dev	1.43	1.43		
Variance	2.04	2.04		
Alpha	0.38	0.41		
1	CSS-Q1-Factual-D-1	CCS-Q2-Factual-D-1		
2	CCS-Q3-Conceptual-D-2	CCS-Q4-Conceptual-B-2		
3	CCS-Q5-Conceptual-B-2	CCS-Q6-Conceptual-A-2		
4	CCS-Q7-Procedural-C-3	CCS-Q8-Conceptual-B-2		
5	CCS-Q9-Conceptual-C-2	CCS-Q10-Conceptual-B-2		
6	CCS-Q11-Factual-B-1	CCS-Q12-Procedural-B-3		
7	CCS-Q13-Procedural-A-3	CCS-Q14-Procedural-C-3		
8	CCS-Q15-Procedural-B-3			

Table 46 indicates that the fifteen items of this questionnaire were split into two parts with alternate numbers. Items 1, 3, 5, 7, 9, 11, 13 and 15 constituted the first half, and items 2, 4, 6, 8, 10, 12 and 14 constituted the second half. The first half had a mean of 3.75 and an alpha value of 0.38. The second half had a mean of 3.85 and an alpha value of 0.41. Both halves had the same standard deviation and variance, 1.43 and 2.04 respectively. The correlation of the scores for the first and second halves was 0.59, which is almost half of a perfect correlation of 1.00. The reliability of instrument calculated with Guttman's split-half test was 0.74.

4.4.2 Climate Change Pedagogical Literacy Questionnaire (CCPLQ)

4.4.2.1 Confidence Interval and Standard Error of Mean of Climate Change Pedagogical Literacy

Table 47: Mean and confidence interval for climate change pedagogy

Variable	Valid N	Mean	Confidence Interval		Median	Min	Max	SDev	SEM
			-95%	95%					
Aims and significance of climate change education	194	3.38	3.13	3.63	3	0	8	1.77	0.13
Constructivist teaching principles	194	4.74	4.32	5.15	5	0	14	2.92	0.21
CCP	194	8.11	7.61	8.62	8	0	18	3.54	0.25

Table 47 shows that the observed mean score for the 194 FET Geography teachers on the assessment of CCPL was 8.11, which is higher than the mean at the -95% confidence interval and less than the mean at the 95% confidence interval. A median score of 8 entails that 8 is the middle score if all the scores for the 194 participants are lined up from the least to the highest. None of the participants scored 0 on the entire test, whereas the maximum score obtained was 18 out of 22, which is the load. A standard deviation of 3.54 implies that the scores were not clustered around the mean but were spread out. The mean score of 3.38 on aim and significance of CCE and 4.74 on constructivist teaching imply that the participants scored higher on the latter variable. In both cases, the means lie between the -95% and 95% confidence intervals. Also, in both cases the minimum score was zero and maximum scores were 8 and 14 respectively. Scores on aim and significance of climate change education are clustered more around the mean than scores on constructivist teaching. Standard error of mean for aims/significance of CCE and constructivist teaching were 0.13 and 0.21 respectively, and 0.25 for CCP. Based on the figures in Table 47, the study concludes that the mean scores on the entire assessment on CCPL lie between the -95% and 95% confidence intervals, with SEM 0.25.

4.4.2.2 Internal Consistency of Items

Table 48: Results of Cronbach's test of internal consistency of CCPLQ items

Variable	Mean if detected	Variance if deleted	Item total Correlation	Alpha if deleted
CCP-Q1-Conceptual-B-2	3.66	1.66	-0.13	0.36
CCP-Q2-Factual-D-1	3.35	1.58	0.02	0.29
CCP-Q3-Conceptual-A-2	3.3	1.45	0.31	0.13
CCP-Q4-Factual-C-1	3.62	1.5	0.22	0.18
CCP-Q5-Conceptual-D-2	3.68	1.58	0.05	0.27
CCP-Q6-Conceptual-D-2	3.3	1.45	0.31	0.13
CCP-Q7-Procedural-C-3	3.7	1.63	-0.06	0.31
CCP-Q8-Procedural-D-3	3.73	1.57	0.01	0.25
CCP-Q9-Procedural-C-3	3.48	1.56	0.06	0.27
CCP-Q10-Procedural-D-3	3.74	1.57	0.01	0.25
		TOTAL	**0.35**	**0.27**

The data in Table 48 indicate that among the ten items of the CCPLQ, two had a negative item total correlation, with -0.13 for Q1 and -0.06 for Q7. Deleting Q1 from the scale would enhance alpha from 0.27 to 0.36, and deleting Q7 from the scale would lead of an increase of alpha from 0.27 to 0.31. Deleting items such as Q3, Q4 and Q6 would result in a remarkable decrease in the reliability of the instrument. These values indicate that CCPLQ contains items that correlated poorly with other items in the scale. With Cronbach's test the CCPLQ has an item total correlation of 0.35 and an alpha of 0.27.

Table 49: Results of Guttman's split-half test of reliability of CCPLQ

N=194	Summary of 1ST Half	Summary of 2nd Half	Corr. of 1st and 2nd Half	Guttman's Split Half Reliability
No. of items	5	5	0.93	0.17
Mean	1.93	2.03		
Sum	3.73	3.93		
Std. Dev	1.2	1.2		
Variance	1.11	1.11		
Alpha	0.46	0.39		
1	CCP-Q1-Conceptual-B-2	CCP-Q2-Factual-D-1		
2	CCP-Q3-Conceptual-A-2	CCP-Q4-Factual-C-1		
3	CCP-Q5-Conceptual-D-2	CCP-Q6-Conceptual-D-2		
4	CCP-Q7-Procedural-C-3	CCP-Q8-Procedural-D-3		
5	CCP-Q9-Procedural-C-3	CCP-Q10-Procedural-D-3		

The data in Table 49 indicate that, when the items of the CCPLQ were split into two halves, a correlation of 0.93 was obtained. The first half contains Q1, Q3, Q5, Q7 and Q9 and the second half contains Q2, Q4, Q6, Q8 and Q10. The first half had a mean of 1.93 and an alpha value of 0.46. The second half had a mean of 3.39 with an alpha value of 0.39. When combined, both halves yielded a reliability coefficient of 0.17, even though both halves had a correlation of 0.93, which is closer to 1.00 (perfect correlation). Based on Guttman's Split-half test, the CCPLQ has a reliability coefficient of 0.17.

4.4.3 Correlation of Climate Change Science Literacy Scores and Climate Change Pedagogical Literacy Scores

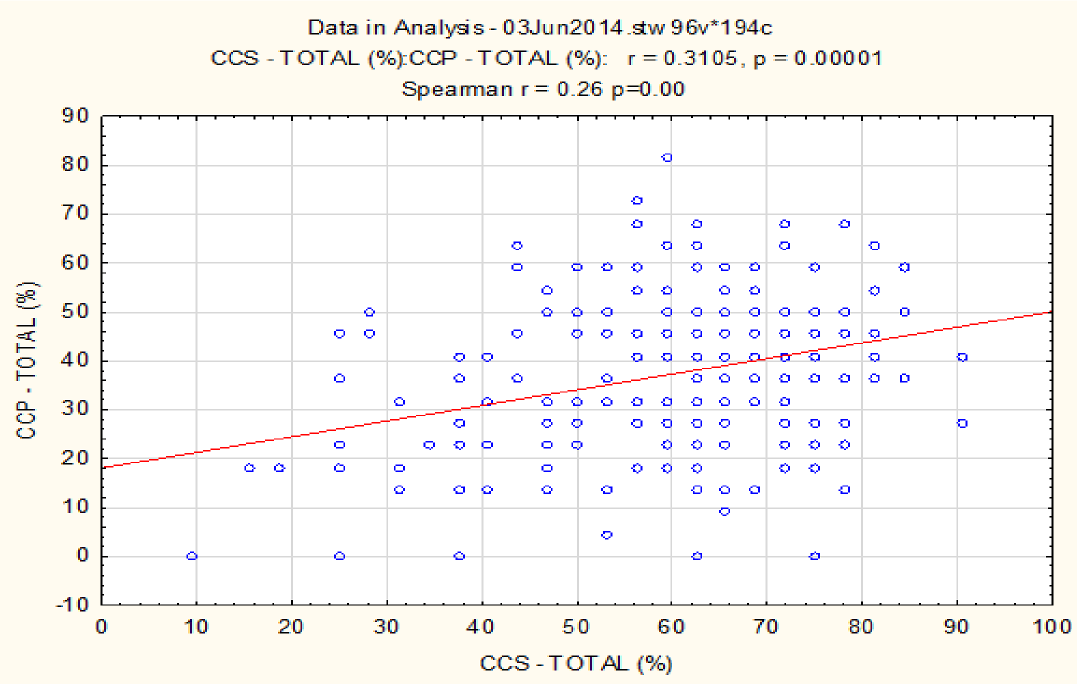

Figure 13: Results of Spearman's test of correlation between CCSL and CCPL scores

The data in Figure 13 indicate that, when the percentage scores obtained by the respondents on CCSLQ and CCPLQ were correlated using Spearman's test, a value of 0.26 (p = 0.000) was obtained. Correlation coefficient *r* measures the power and direction of a linear relationship between two variables on a scatterplot. Looking closely at the dots and how they are scattered shows that there are more outliers in CCS than CCP scores. Besides Spearman values, the standard correlation r was 0.31 (p = 0.00001). Even though 0.26 and 0.31 are indications of positive correlation, they are far from halfway to 1.00. Thus, an analysis of the graphs indicates that there was a very low positive correlation (0.26) between the CCSL scores and the CCPL scores. The values show that CCSL scores increase as CCPL scores increase, that is uphill (positive) linear relationship, but the strength of the increase is very small as the values are far distanced from +1.00. This result implies that teachers with higher CCSL scores do not tend to have higher CCPL scores. With this result, a teacher's CCSL score alone cannot be used to predict his or her CCPL score.

4.5 THE RESPONDENTS' SCORES IN CLIMATE CHANGE SCIENCE LITERACY

4.5.1 Level of Literacy in Climate Change Science

Table 50: Levels of literacy in climate change science

Variable	N	0-20 Very Low		21-40 Low		41-60 High		61-80 Very High		81-100 Excellent	
		N	%	n	%	n	%	n	%	N	%
Climatic processes and causes of climate change	194	1	0.52	32	16.49	16	8.25	87	44.85	57	29.38
Climate change impacts	194	23	11.9	25	12.89	47	24.23	42	21.65	57	29.38
Climate change responses	194	9	4.64	28	14.43	70	36.08	65	33.51	22	11.34
CCS	**194**	**3**	**1.55**	**28**	**14.43**	**63**	**32.47**	**89**	**45.88**	**11**	**5.67**

Table 50 shows that, regarding climatic processes and probable causes of climate change, 0.52% of the sample demonstrated very low literacy, 16.49% demonstrated low literacy, 8.25% demonstrated high literacy, 44.85% demonstrated very high literacy, and 29.38% demonstrated excellent literacy. These figures indicate that the majority of the participants (44.85%) demonstrated very high literacy in climatic processes and probable causes of climate change. Regarding climate change impacts, 11.9% demonstrated very low literacy, 12.89% demonstrated low literacy, 24.23% demonstrated high literacy, 21.65% demonstrated very high literacy, and 29.38% demonstrated excellent literacy. On the basis of these figures, the study concludes that the majority of geography teachers (29.38%) showed excellent literacy in climate change impacts. Pertaining to climate change responses, 4.64% demonstrated very low literacy, 14.43% demonstrated low literacy, 36.08% demonstrated high literacy, 33.51% demonstrated very high literacy, and 11.34% demonstrated excellent literacy. Based on the data in Table 50, the study concludes that the majority of teachers demonstrated high literacy regarding climate change responses. On CCS as a whole, 1.55% of the respondents demonstrated very low literacy, 14.43% demonstrated low literacy, 32.47% demonstrated high literacy, 45.88% demonstrated very high literacy, and 5.67% were excellent. On the basis of these figures, the majority of 152 respondents demonstrated very high literacy in CCS. Details of the respondents' responses to CCS items are provided in the histograms in Section 4.5.2.

4.5.2 Frequency Distribution of the Responses to Climate Change Science Items

Sections 4.5.2.1 to 4.5.2.3 presents the respondents' answers to items in the three domains of climate change science: climatic processes and probable causes of climate change, climate change impacts and climate change responses.

4.5.2.1 Responses to climatic processes and probable causes of climate change items

Question 1

One of these options is the most abundant greenhouse gas and also the most important contributor to natural greenhouse effect.

A. Methane

B. Carbon dioxide

C. Water vapour

D. Nitrous oxide

Keyed option is **C**. Question is Factual. Weight is 1.

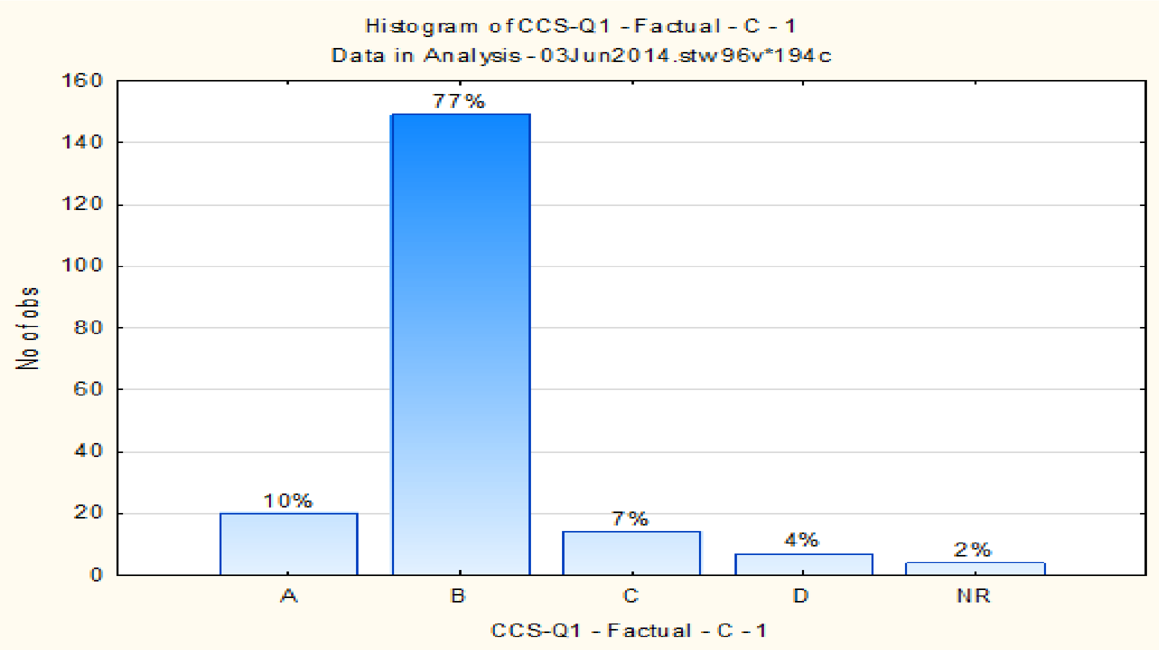

Figure 14: Histogram showing the frequency and percentage of responses to CCS – Question 1

The data in Figure 14 show that 10% of the participants chose A (methane) as the correct answer, 77% chose B (carbon dioxide); 7% chose C (water vapour); 4% of the participants chose D (nitrous oxide), and 2% of the participants did not respond to the item. This study concluded that the majority (93%) of the respondents did not know that water vapour is the most abundant greenhouse gas and also the most important contributor to the natural greenhouse effect in the atmosphere.

Question 2

The term *global warming* refers to

A. a high concentration of carbon dioxide in the lower atmosphere

B. rapid changes in dynamics and processes of the climate system

C. changes in global climate and local weather patterns

D**.** increase in the average temperature of the Earth's atmosphere

Keyed option is **D**. Question is Factual. Weight is 1.

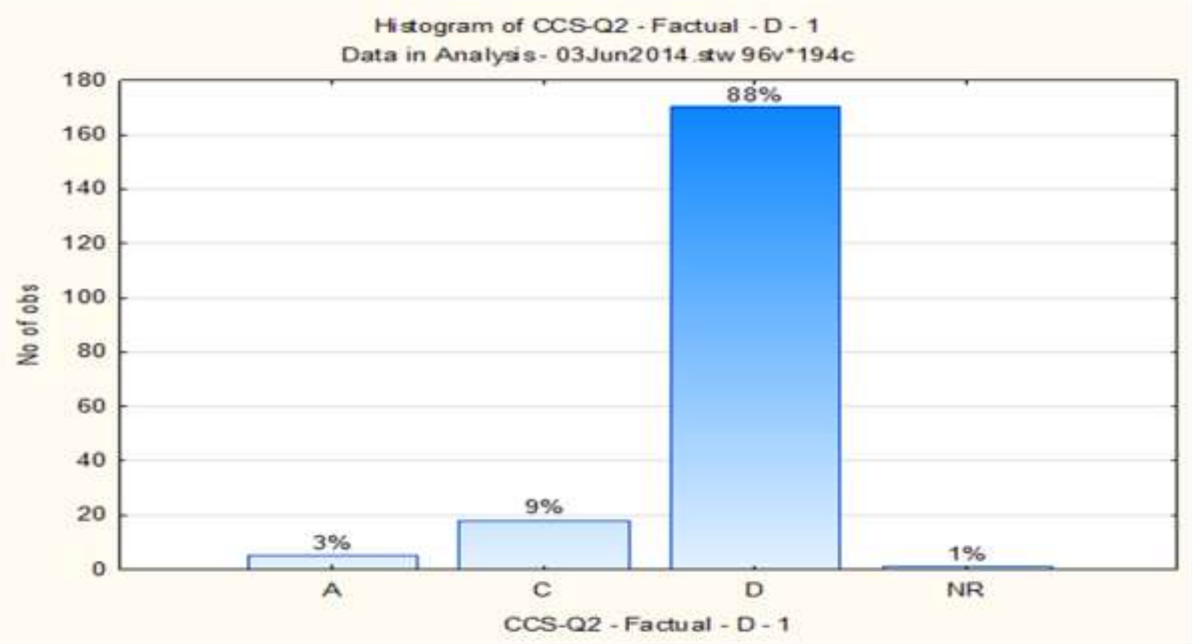

Figure 15: Histogram showing frequency and percentage of responses to CCS – Question 2

Figure 15 shows that 3% of the participants chose A; 9% chose C; 88% chose D; and, 1% did not respond to the question. On the basis the data presented, the majority (88%) of the respondents knew that global warming refers to an increase in the average temperature of the Earth's atmosphere.

Question 3

Which of the options below is an anthropogenic cause of climate change?
A. Slow drifting of continents over millions of years
B. Inconstant intensity of radiation emitted by the sun
C. Volcanic eruptions that inject ash and sulphur compounds into the atmosphere
D. Release of industrial greenhouse gases into the lower atmosphere
Keyed option is D. Question is Conceptual. Weight is 2.

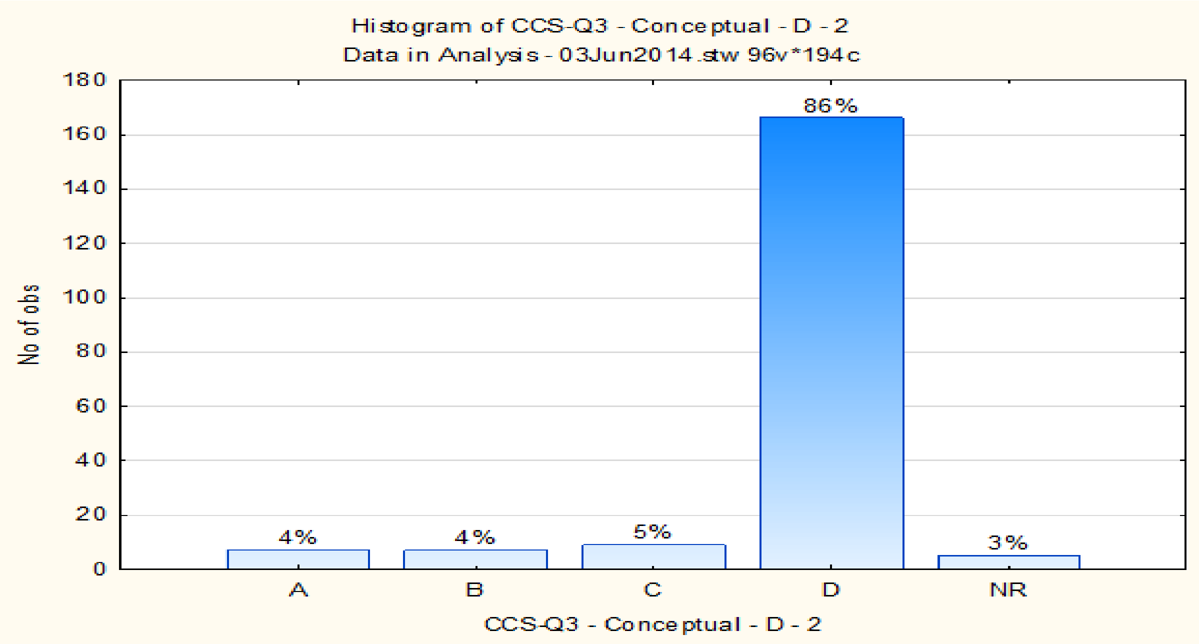

Figure 16: Histogram showing frequency and percentage of responses to CCS – Question 3

Figure 16 shows that Item 3 is a conceptual question and the keyed option is D. Of 194 respondents, 4% chose A, 4 chose B, 5% chose C and 86% chose D. Three per cent of the respondents did not respond to the question. On the basis of data in the graph, the majority (86%) of the respondents understood that the release of industrial greenhouse gases into the lower atmosphere was an anthropogenic cause of climate change.

Question 4

Choose from the options below the correct statement, given the amount of CO_2 currently in the Earth's atmosphere.

A. There will be a reduction of global warming in the next few decades

B. Global warming will continue for many centuries

C. Developing countries will experience less warming

D. Highly industrialised countries will experience less warming

Keyed option is B. Question is Conceptual. Weight is 2.

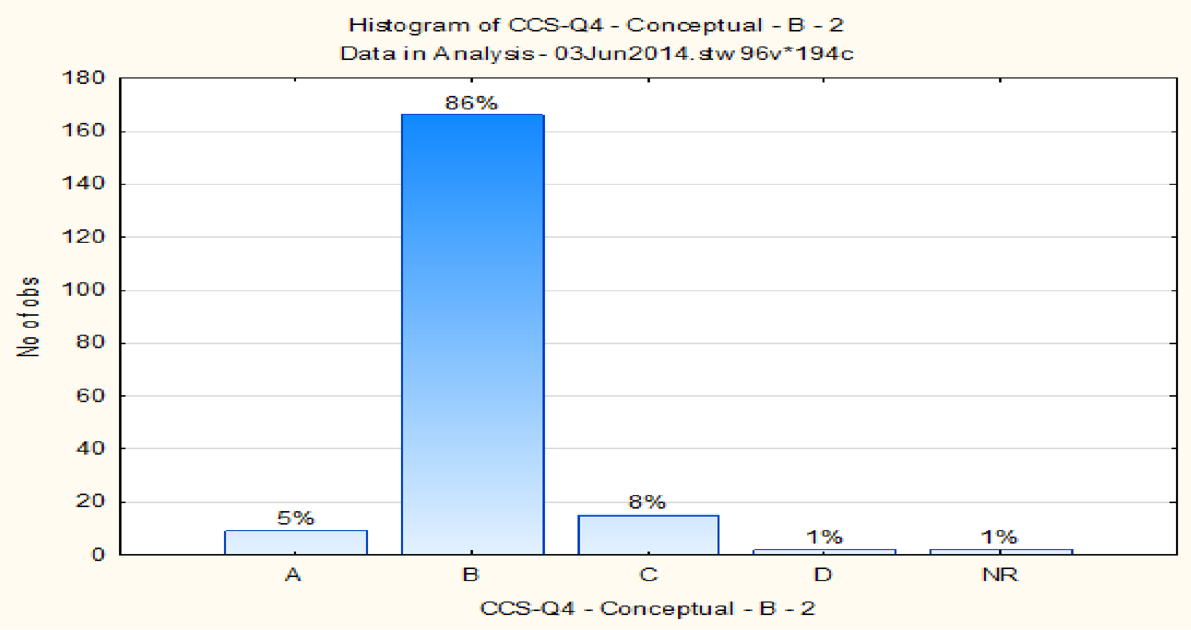

Figure 17: Histogram showing the frequency and percentage of responses to CCS – Question 4

Figure 17 shows that Question 4 is a conceptual question and the keyed option is B. The results indicate that 5% of the participants believed that there would be a reduction in global warming in the next few decades; 86% believed that global warming would continue for many centuries; 8% believed that developing countries will experience less warming; 1% believed that highly industrialised countries will experience less warming; and 1% did not choose any of the options. On the basis of the responses shown on Figure 19, this study concludes that the majority (86%) of respondents believed that global warming would continue for many centuries.

Question 5

This question required the participants to choose from the options listed below the one that is a feature of climate change science.

A. Precision

B. Uncertainty

C. Consensus

D. Feedback

Keyed option is B. Question is Conceptual. Weight is 2.

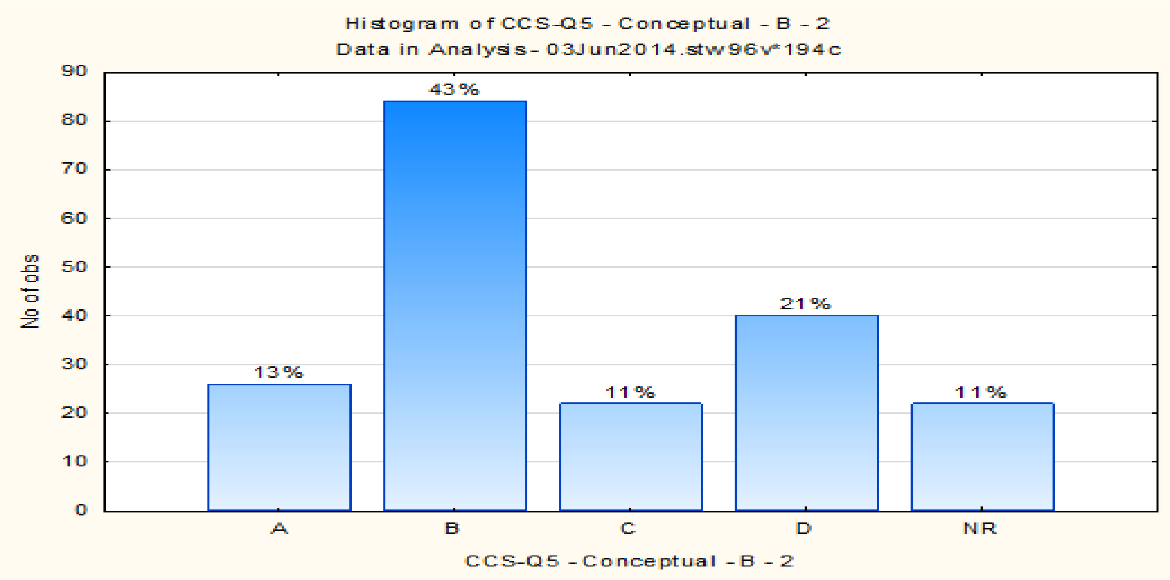

Figure 18: Histogram showing frequency and percentage of responses to CCS – Question 5

The data in Figure 18 show that Question 5 is a conceptual item with B as the keyed option. The responses show that 13% of the participants said that climate change science is characterised by precision; 43% said that climate change science is characterized by uncertainty; 11% said that climate change science is characterised by consensus; 21% said climate change is characterised by feedback; and 11% gave no response. Looking at these responses, this study concludes that the majority (57%) of the participants did not understand that climate change science is characterised by uncertainty.

4.5.2.2 Responses to climate change impacts items

Question 6

Identify from the list provided below the evidence of global warming.

A. Decrease in ice sheets

B. Decrease in global temperature

C. Decrease in sea level

D. Decrease in ocean salinity

Keyed option is A. Question is Conceptual. Weight is 2.

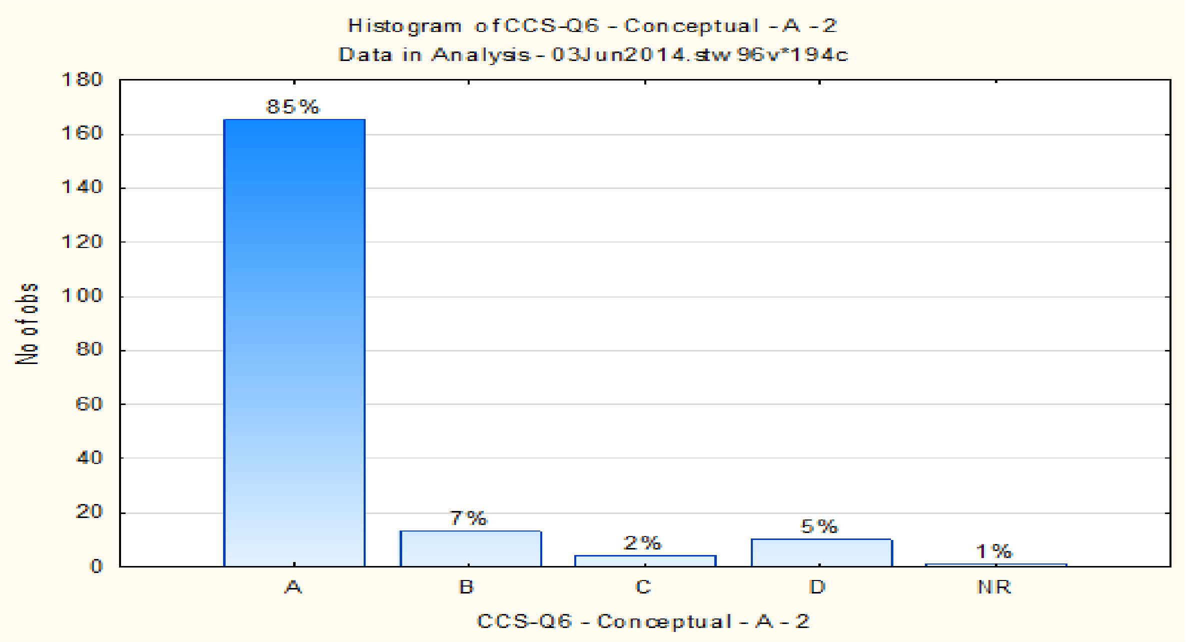

Figure 19: Histogram showing frequency and percentage of responses to CCS – Question 6

The data in Figure 19 show that of 194 FET Geography teachers who participated in this study, 85% were of the view that a decrease in ice sheets is evidence of global warming. 7% identified a decrease in global temperature as evidence of global warming, 2% identified a decrease in sea level as evidence of global warming, 5% identified a decrease in ocean salinity as evidence of global warming and 1% did not answer this question. Based on the pattern of the responses, the majority (85%) of the respondents correctly identified a decrease in ice sheets as evidence of global warming.

Question 7

Atmospheric supply of moisture in an area minus atmospheric demand for moisture in that area can give an indication of

A. heat waves

B. disease outbreaks

C. droughts

D. floods

Keyed option is C. Question is Procedural. Weight is 3.

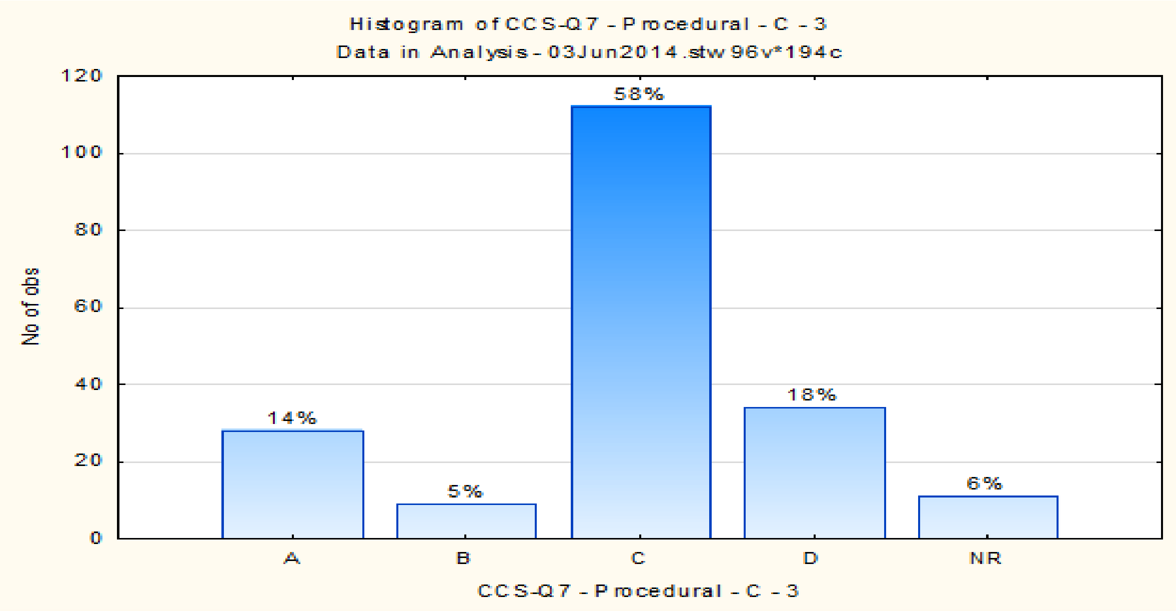

Figure 20: Histogram showing frequency and percentage of responses to CCS – Question 7

The data presented in Figure 20 show that 14% of the participants in this study responded that atmospheric supply of moisture in an area minus atmospheric demand for moisture in that area can give an indication of heat waves; 5% responded that it is an indication of disease outbreak; 58% said it is an indication of droughts; and 18% indicated that it gives an indication of floods. Considering that the correct answer is droughts, this study concludes that 58% (the majority) of the respondents understood that atmospheric supply of moisture in an area minus atmospheric demand for moisture in that area can give an indication of droughts.

Question 8

Most sub-Saharan African countries are vulnerable to climate change because they have

A. low CO_2 emissions per capita

B. poor capacity to adapt to climate changes

C. high CO_2 emissions per capita

D. good capacity to adapt to climate changes

Keyed option is B. Question is Conceptual. Weight is 2.

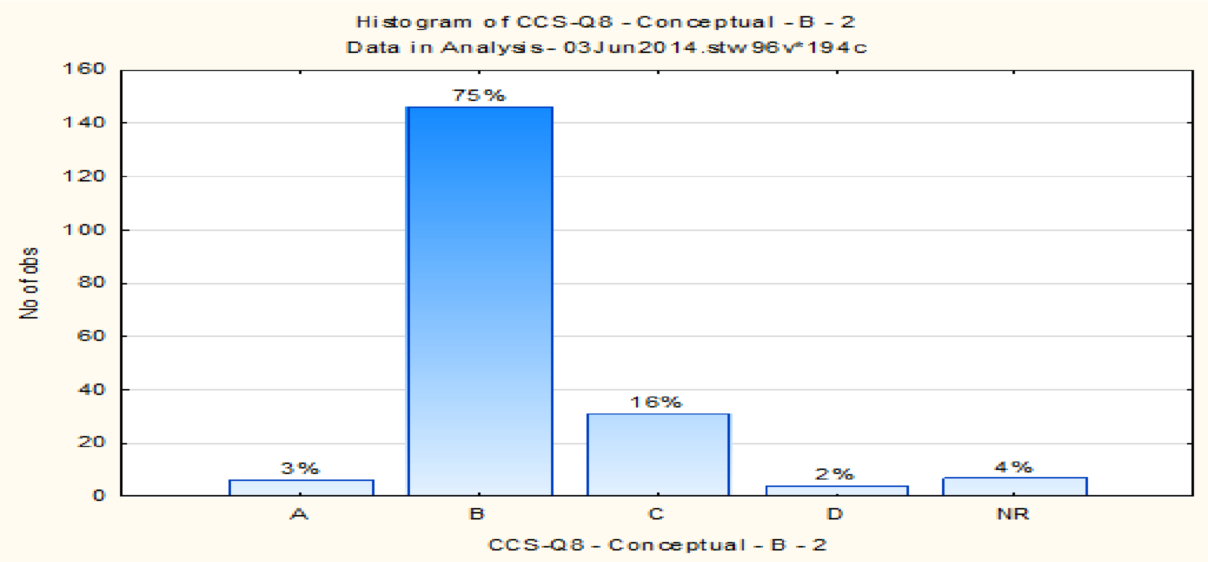

Figure 21: Histogram showing frequency and percentage of responses to CCS – Question 8

Figure 21 shows that 3% of the participants in this study responded that most sub-Saharan African countries are vulnerable to climate change because they have low CO_2 emissions per capita; 75% responded that they are vulnerable to climate change because they have poor capacity to adapt to climate changes; 16% responded that they are vulnerable to climate change because they have high CO_2 emissions per capita; 2% responded that most they are vulnerable to climate change because they have good capacity to adapt to climate changes; and 4% did not respond to the question. Looking at the keyed option which is B, the majority (75%) of the respondents understood that most sub-Saharan African countries are vulnerable to climate change because they have poor capacity to adapt to climate changes.

Question 9

Question 9 reads: Which of these options is not caused by climate change in less developed countries?

A. Low out-migration

B. Low income opportunities

C. Low outbreak of diseases

D. Poor service delivery

Keyed option is C. Question is Conceptual. Weight is 2.

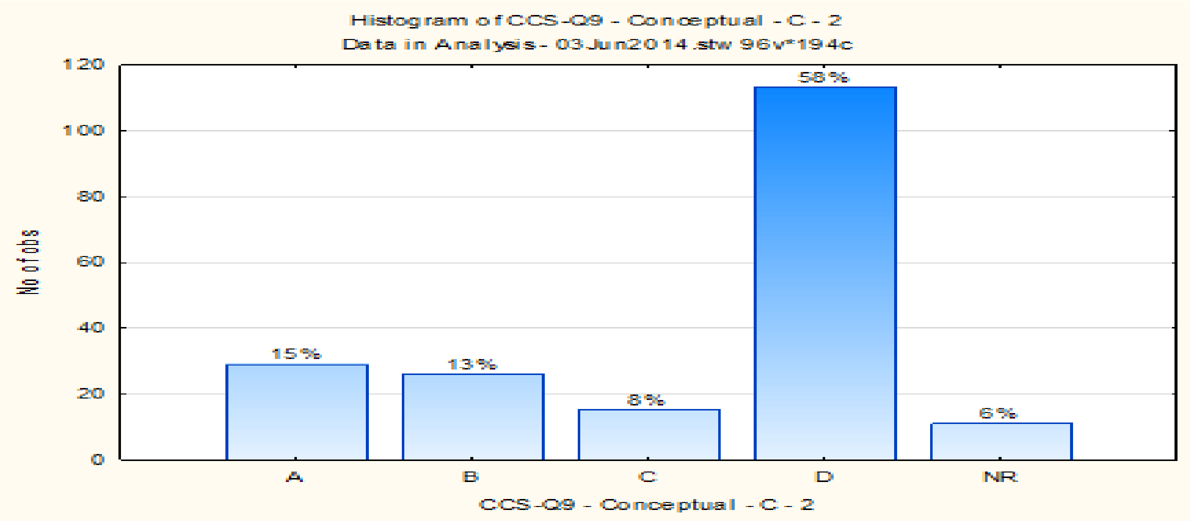

Figure 22: Histogram showing frequency and percentage of responses to CCS – Question 9

The data presented in Figure 22 shows that 15% of the participants believed that low out-migration is not caused by climate change in developing countries; 13% believed that low income opportunities is not caused by climate change in developing countries; 8% believed that low outbreak of diseases is not caused by climate change in developing countries; 58% believed that poor service delivery is not caused by climate change in developing countries; and 6% of the respondents did not respond to the question. With C as the correct answer, only 8% of the participants understood that a low outbreak of diseases is not caused by climate change in developing countries. The majority (58%) were of the opinion that poor service delivery in developing countries could not be the consequence of climate change.

Question 10

Question 10 reads: Too much heat due to an increase in greenhouse warming may have more negative effects on people in the northern hemisphere than people in the southern hemisphere because

A. the northern hemisphere lacks the technology to deal with global warming

B. the northern hemisphere is more populated than the southern hemisphere

C. the southern hemisphere is more populated than the northern hemisphere

D. the southern hemisphere is less vulnerable to global warming impacts

Keyed option is B. Question is Conceptual. Weight is 2.

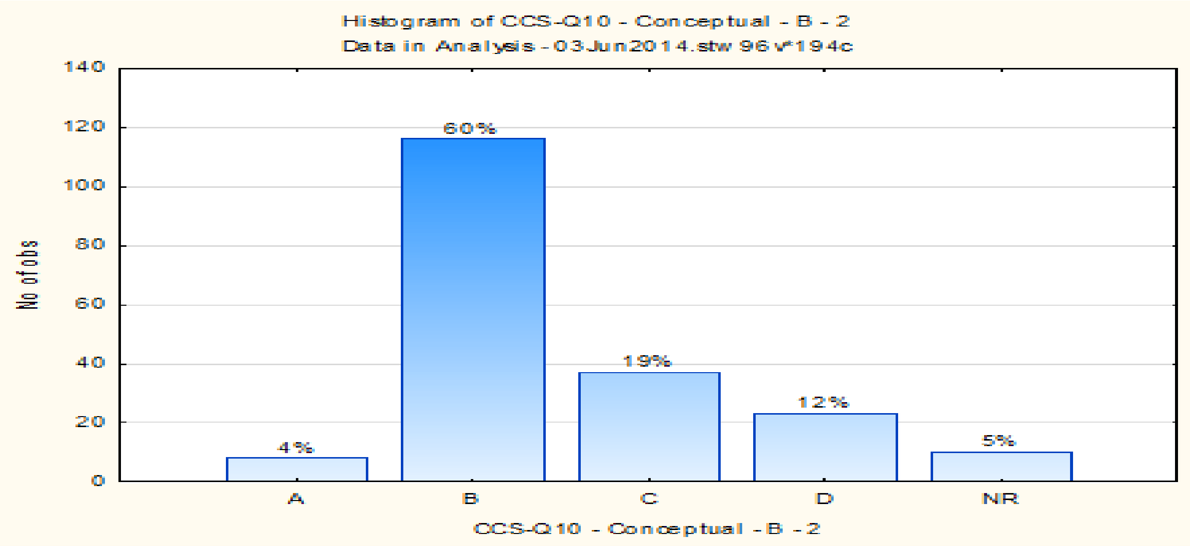

Figure 23: Histogram showing frequency and percentage of responses to CCS – Question 10

Figure 23 shows that 4% of the participants responded that too much heat due to an increase in greenhouse warming may have a more negative effect on people in the northern hemisphere than people in the southern hemisphere because the northern hemisphere lacks the technology to deal with global warming; 60% of the participants responded that too much heat due to an increase in greenhouse warming may have more negative effect on people in the northern than the southern hemisphere because the northern hemisphere is more populated than the southern hemisphere; 19% of the participants responded that too much heat due to an increase in greenhouse warming may have a more negative effect on people in the northern than the southern hemispheres because the southern hemisphere is more populated than the northern hemisphere; 12% of the participants responded that too much heat due to an increase in greenhouse warming may have a more negative effect on people in the northern hemisphere than people in the southern hemisphere because the southern hemisphere is less vulnerable to global warming impacts, and 5% of the respondents did not respond to the question. With B as the keyed option, the study concludes that the majority, which is 60% of FET Geography teachers that participated in this study, believed that too much heat due to an increase in greenhouse warming may have a more negative effect on people in the northern hemisphere than people in the southern hemisphere because the northern hemisphere is more populated than the southern hemisphere.

4.5.2.3 Responses to climate change responses items

Question 11

The term 'carbon sequestration' means

A. interruptions of the carbon cycle by human beings

B. the removal of CO_2 from the atmosphere and depositing it in reservoirs

C. flow of CO_2 through the oceans, biosphere and lithosphere

D. production of large quantities of CO_2 from industrial processes

Keyed option is B. Question is Factual. Weight is 1.

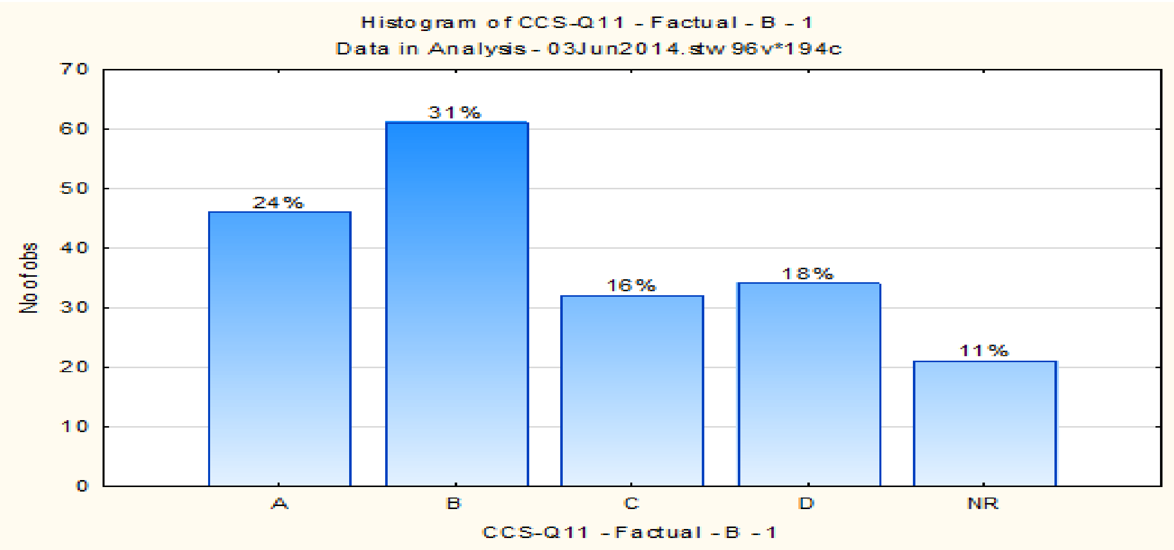

Figure 24: Histogram showing frequency and percentage of responses to CCS – Question 11

The data presented in Figure 24 show that of 194 FET Geography teachers that participated in this study, 24% responded that the term 'carbon sequestration' means interruptions of the carbon cycle by human beings; 31% of them referred to carbon sequestration as the removal of CO_2 from the atmosphere and depositing it in reservoirs; 16% referred to it as flow of CO_2 through the oceans, biosphere and lithosphere; and 11% referred to it as production of large quantities of CO_2 from industrial processes. Considering that the keyed option is B, this study concludes that only 31% of the participants understood that the term carbon sequestration means the removal of CO_2 from the atmosphere and depositing it in reservoirs.

Question 12

One of these is not a community-based adaptation to climate change.

A. Implementing projects aimed at poverty eradication

B. Implementing guidelines to achieve carbon emission reduction targets

C. Establishing disaster-risk reduction centres in rural areas

D. Encouraging local people's participation in natural resource conservation

Keyed option is B. Question is Procedural. Weight is 3.

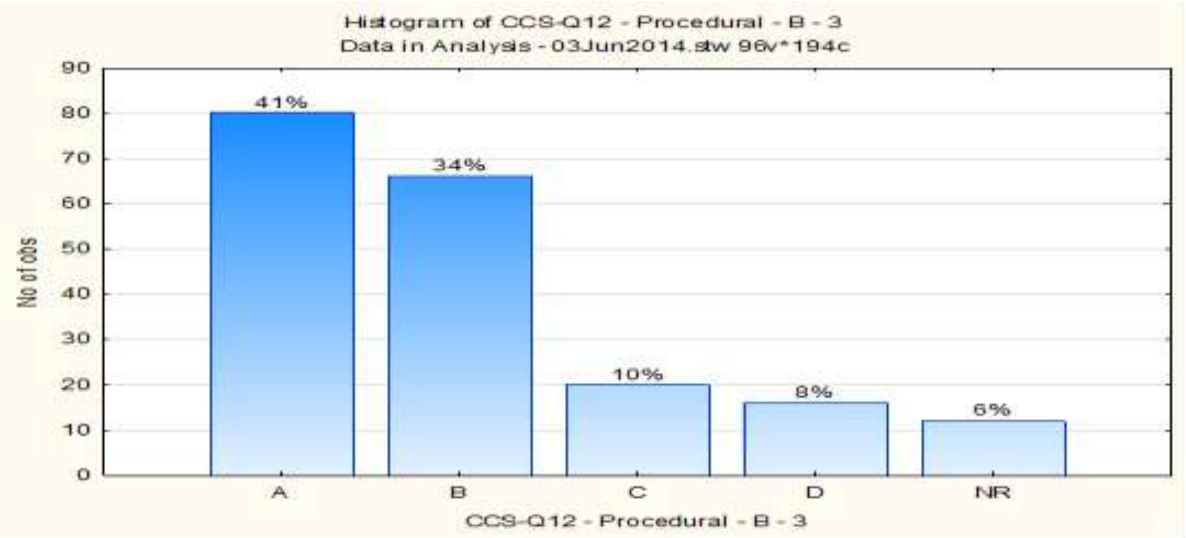

Figure 25: Histogram showing frequency and percentage of responses to CCS – Question 12

Figure 25 shows that, when asked to identify from the options provided one that was not a community-based adaptation to climate change, 41% of the participants chose 'implementing projects aimed at poverty eradication', 34% chose 'implementing guidelines to achieve carbon emission reduction targets', 10% chose 'establishing disaster-risk reduction centres in rural areas', 8% chose 'encouraging local people's participation in natural resource conservation' and 6% did not respond. Considering that the correct option is B, the study concludes that only 34% of the FET Geography teachers (the minority) correctly responded that implementing guidelines to achieve carbon emission reduction targets is not a community-based adaptation to climate change.

Question 13

Which of these may hinder the implementation of new policies on climate change?

A. Ensuring that climate experts alone formulate climate change policies

B. Enhancing the capacity of the media to educate communities about climate change

C. Involving rural communities in climate change discourse

D. Educating children and youth about climate change

Keyed option is A. Question Procedural. Weight is 3.

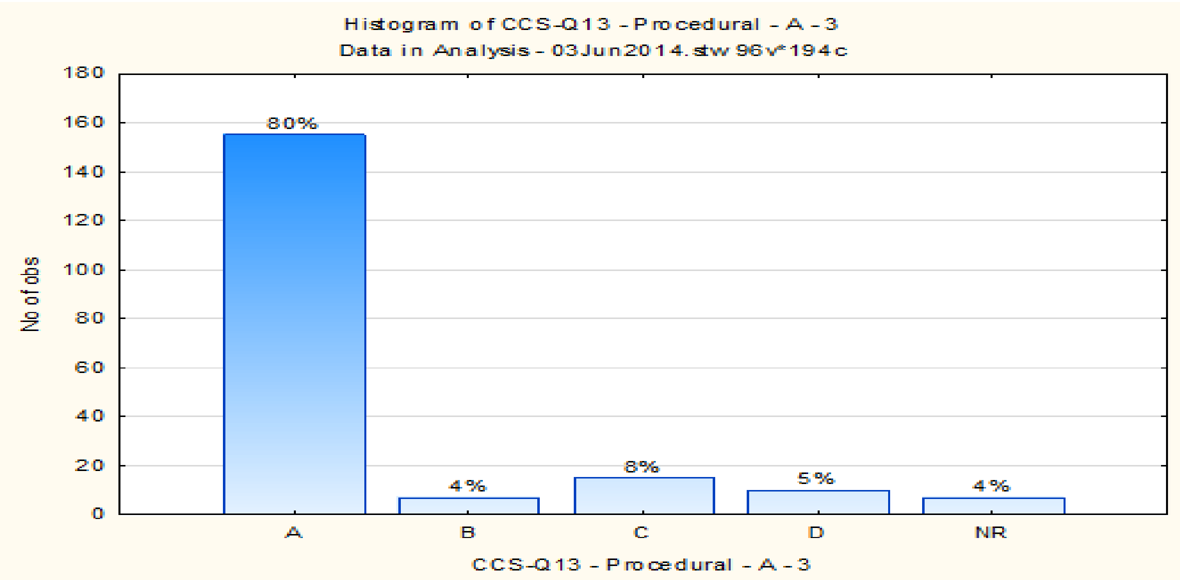

Figure 26: Histogram showing frequency and percentage of responses to CCS – Question 13

The data in Figure 26 show that the participants made diverse responses when asked to identify from a list of options the one that may hinder the implementation of new policies on climate change. Eighty percent of the participants chose ‘Ensuring that climate experts alone formulate climate change policies’; 4% chose ‘Enhancing the capacity of the media to educate communities about climate change’; 8% chose ‘Involving rural communities in climate change discourse’; 5% chose ‘Educating children and youth about climate change; and, 4% did not respond to the question. Taking into consideration that option A is the most correct answer, the majority (80%) of the respondents hold that ensuring that climate experts alone formulate climate change policies may hinder the implementation of new policies on climate change.

Question 14

Which of the options below is the best for developing countries, if climate change does not stop soon?

A. Reduce the amount of greenhouse gas in the atmosphere

B. Carry on with business as usual until climate change stops

C. Implement programmes that will reduce the harmful effect of climate change

D. Search for more scientific information on present and future climate changes

Keyed option is C. Question is Procedural. Weight is 3.

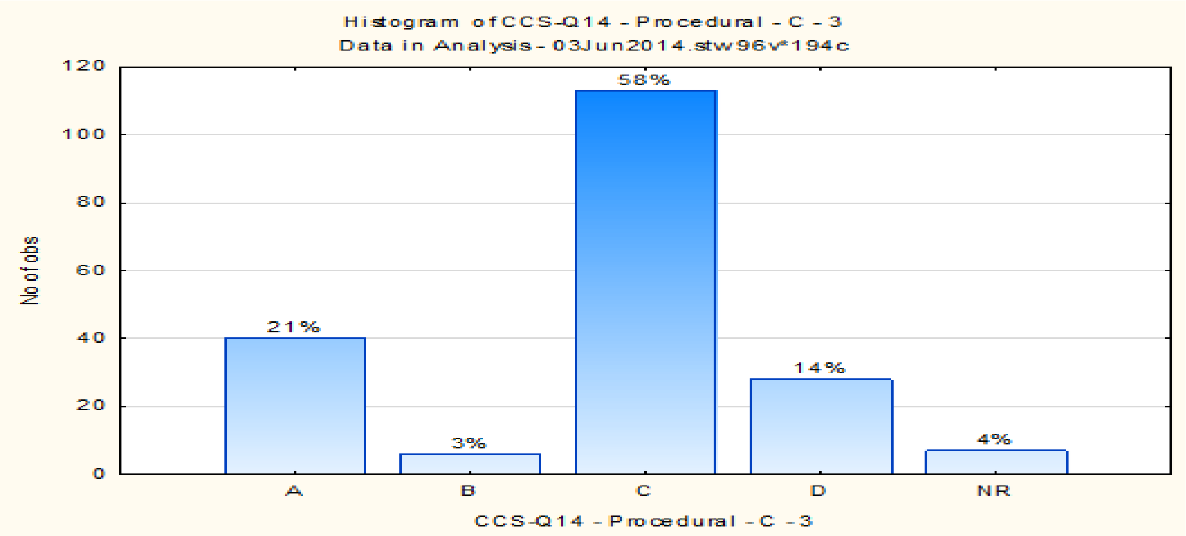

Figure 27: Histogram showing frequency and percentage of responses to CCS – Question 14

Figure 27 shows that, when the participants were asked the best option for developing countries if climate change did not stop soon, 21% of them indicated 'Reduce the amount of greenhouse gas in the atmosphere'; 3% indicated 'Carry on with business as usual until climate change stops'; 58% indicated 'Implement programmes that will reduce the harmful effect of climate change'; 14% indicated 'Search for more scientific information on present and future climate changes'; and 4% did not respond to the question. In view of the pattern of response, the majority (58%) of the participants indicated that the implementation of programmes that would reduce the harmful effect of climate change was best for developing countries if climate change stayed unabated.

Question 15

One of these initiatives is associated with South Africa.

A. COP16/CMP6

B. COP17/CMP7

C. COP18/CMP8

D. COP19/CMP9

Keyed option is B. Question is Procedural. Weight is 3.

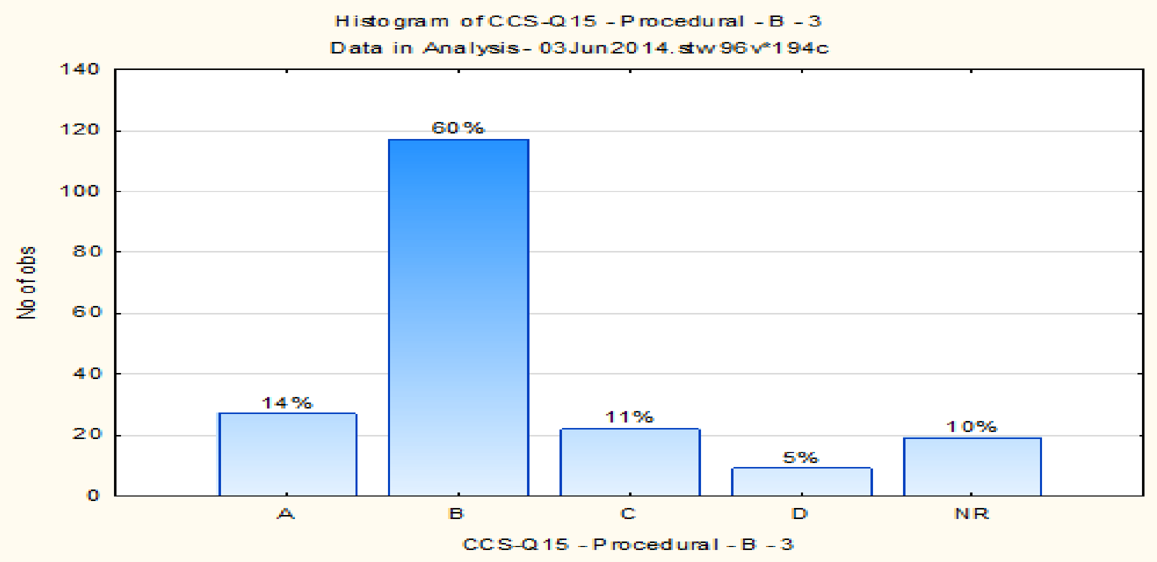

Figure 28: Histogram showing frequency and percentage of responses to CCS – Question 15

The data in Figure 28 show that 14% of the participants responded that COP16/CMP6 is associated with South Africa; 60% responded COP17/CMP7; 11% responded COP18/CMP8; 5% responded COP19/CMP9; and, 10% did not respond. It is drawn from the observation that 60% (the majority) of the FET Geography teachers that took part in this study understood COP17/CMP7 as a climate change initiative associated with South Africa.

4.5.2.4 Misconceptions

Through the analysis of performance on individual items in the CCSLQ, it was observed that 93% of the participants did not know that water vapour is the most abundant greenhouse gas and also the most important contributor to the natural greenhouse effect in the atmosphere. Fifty-seven per cent of the participants did not know that climate change science characterised by uncertainty; 92% of the participants believed that outbreak of diseases in developing countries is mainly due to climate change; 79% of the participants did not know the meaning of the term ‘carbon sequestration; and only 34% of the participants understood that implementing guidelines to achieve carbon emission reduction targets is not a community-based adaptation to climate change

4.6 THE HYPOTHESES ON CLIMATE CHANGE SCIENCE LITERACY

The hypotheses on CCS are based on data from the following variables:

- School location
- Gender
- Age
- Qualification
- Specialisation
- Teaching experience
- Grade mostly taught
- Experience in teaching lessons on climate change

4.6.1 School Location

- Ho1: There are no significant differences in the distributions of the scores of the categories of school location on literacy regarding climate change science.

Table 51: Results of Kruskal-Wallis test difference in literacy in climate change science between the categories of school location

Variable	Rural	Urban	Semi Urban	Total p
Processes and causes of climate change	R:119.9	R:97.44	R:83.91	**0.05**
Rural		0.26	0.06	
Urban	0.26		0.62	
Semi Urban	0.06	0.62		
Climate change impacts	R:106.64	R:100.32	R:74.99	**0.02**
Rural		1	**0.05**	
Urban	1		**0.05**	
Semi Urban	**0.05**	**0.05**		
Climate change responses	R:108.64	R:101.32	R:74.99	**0.03**
Rural		1	0.09	
Urban	1		**0.04**	
Semi Urban	0.09	**0.04**		
CCS	R:117	R:102.68	R:68.27	**0.0004**
Rural		0.82	**0.002**	
Urban	0.83		**0.001**	
Semi Urban	**0.002**	**0.001**		

p ≤ 0.5 reject Ho. p > .05 accept Ho.

The data in Table 51 shows that there was a significant difference between geography teachers from schools located in rural, urban and semi-urban areas on the three variables of climate change science literacy. The processes and causes of climate change p-value of 0.05 equals critical p-value 0.05. Hence, there was no significant difference between the three school location types on literacy of processes and causes of climate change. Climate change impacts p-value 0.02 < 0.05, hence Ho is rejected and it is concluded that a significant difference exists among the schools in the three locations. In terms of literacy of climate change responses, p 0.03 < 0.05 and for this reason Ho is rejected; hence there is a significant difference existed between schools in the three location types in terms of literacy in climate change solutions. In total, p .0004 < 0.05, therefore Ho1 is rejected, implying that there is a significant difference in the distributions of the scores of school location on literacy in climate change science.

4.6.2 Gender

- Ho2: There are no significant differences in the distributions of the scores of gender on literacy regarding climate change science.
-

Table 52: Results of Mann-Whitney U Test on literacy in climate change science between the categories of gender

Variable	Gender		Ranked Sum Female	Ranked Sum Male	U	Z	P-value
	Female	Male					
Processes and causes of climate change	87	107	7999	10916	4171	-1.24	0.21
Climate change impacts	87	107	7675	11240	3847	-2.07	**0.04**
Climate change responses	87	107	7475	11440	3647	-2.59	**0.01**
CCS	87	107	7328	11587	3500	-2.97	**0.000**

$p \leq 0.5$ reject Ho. $p > .05$ accept Ho.

The data presented in Table 52 shows that the climatic processes and causes of climate change calculated p-value of 0.21 is greater than critical p-value of 0.05. This value indicates that there is no significant difference in the distributions of the scores of the categories of gender on literacy in climatic processes and probable causes of climate change. Pertaining to climate change impact and climate change responses, calculated p-values of 0.04 and 0.01, respectively, are less than the critical of p-value 0.05. This implies that there is a significant difference in the distributions of the scores of the categories of gender on literacy in climate change impact and climate change responses. In total (CCS), calculated p-value of 0.01 is less than the critical p-value of 0.05. Hence Ho2 is rejected - a significant difference was observed in the distributions of the scores of the categories of gender on literacy in CCS, with the males having an edge over the females. It could be that that men show more concern or interest in climate change issues than women.

4.6.3 Age

- Ho3: There are no significant differences in the distributions of the scores of the categories of age on literacy in climate change science.

Table 53: Results of Mann-Whitney U Test on literacy in climate change science between the categories of age

Variable	Age		Ranked Sum <40	Ranked Sum >40	U	Z	P-value
	<40	>40					
Processes and causes of climate change	38	156	3482.5	15238.5	2741	-0.66	0.51
Climate change impacts	38	156	3206	15615	2455	-1.56	**0.12**
Climate change responses	38	156	2981.5	15739.5	2240.5	-2.28	**0.02**
CCS	38	156	2840	15881	2099	-2.74	**0.01**

p ≤ 0.5 reject Ho. p > .05 accept Ho.

The data in Table 53 shows that the obtained p-value on climatic processes and causes of climate change of 0.51 is greater than the critical p-value of 0.05; hence there is no significant difference in the distribution of scores of the categories of age on literacy in climatic processes and causes of climate change between geography teachers aged over 40 years and those younger than 40 years. The obtained p-value of 0.12 on climate change impact is greater than 0.05; therefore no significant difference was found between geography teachers over 40 years of age and those younger than 40 years of age on literacy of climate change impacts. The obtained p-value of 0.02 on climate change responses is less than the critical value of 0.05; therefore, a significant difference was found in literacy regarding climate change responses between Geography teachers over 40 years of age and those younger than 40 years of age. On entire climate change science, the obtained p-value of 0.01 is less than the critical value of 0.05; hence the study concludes that there is a significant difference in the distributions of the scores of the categories of age on literacy in CCS.

4.6.4 Qualification

- Ho4: There are no significant differences in the distributions of scores of qualification on literacy in climate change science.

Table 54: Results of Mann-Whitney U Test on literacy in climate change science between the categories of qualification

Variable	Masters	PG Dip	Bach	Hons.	Ord. Dip	NR	Total p
Processes/causes of climate change	R:234.06	R:93.91	R:81.93	R:113.26	R:97.48	R:130.5	0.14
Masters		0.99	0.19	1	1	1	
PG Diploma	0.99		1	1	1	1	
Bachelor	0.19	1		**0.04**	1	1	
Honours	1	1	**0.04**	1	1	1	
Ordinary Diploma	1	1	1	1		1	
NR	1	1	1	1	1		
Climate change impacts	R:78.06	R:106.58	R:90.03	R:107.38	R:92.38	R:36.5	**0.27**
Masters		1	1	1	**1**	1	
PG Diploma	1		1	1	**1**	1	
Bachelor	1	1		1	**1**	1	
Honours	1	1	1		**1**	1	
Ordinary Diploma	1	1	1	1		1	
NR	1	1	1	1	1		
Climate change responses	R:126.06	R:93.23	R:93.49	R:105.75	R:99.98	R:162	**0.19**
Masters		1	0.8	1	1	1	
PG Diploma	1		1	1	1	1	
Bachelor	0.8	1		1	1	1	
Honours	1	1	1		**1**	**1**	
Ordinary Diploma	1	1	1	1		1	
NR	1	1	1	1	1		
CCS	R:120.06	R:96.93	R:81.46	R:111.86	R:99.39	R:106	**0.07**
Masters		1	0.97	1	1	1	
PG Diploma	1		1	1	1	1	
Bachelor	0.97	1		005	1	1	
Honours	1	1	0.05		1	1	
Ordinary Diploma	1	1	1	1		1	
NR	1	1	1	1	1		

p ≤ 0.5 reject Ho. p > .05 accept Ho.

Table 54 shows that there is no statistically significant difference in observation of scores of climatic processes and probable causes of climate change for the categories of qualification based on the fact that observed p-value of 0.27 is greater than the critical p-value of 0.05. However, a significant difference was found between holders of Bachelor and Honours qualifications on processes/causes of climate change, as the obtained p-value of 0.04 is less than the critical p-value of 0.5. No statistically significant difference was found between observations from the various qualifications in terms of climate change impact and climate change responses. Although a significant difference was found between observations from participants with Bachelors and Honours qualifications, there was no statistically significant difference in observation of scores on climate change science pertaining to the qualification categories as observed p-value of 0.07 is greater than 0.05 critical p-value. On the grounds of the data presented, Ho4 is rejected; hence there is no significant difference in the distributions of the scores of qualification on literacy in CCS.

4.6.5 Subject specialisation

- Ho5: There are no significant differences in the distributions of the scores of specialisation on literacy in climate change science.

Table 55: Results of Mann-Whitney U Test on literacy in climate change science between the categories of specialisation

Variable	Geo/Edu	Geo only	Others	Geo/another subject	NR	Total p
Processes and P causes of climate change	R:95.84	R:103.5	R:78.38	R:100.7	R:130.5	**0.42**
Geography/Education		1	1	1	1	
Geography only	1		0.77	1	1	
Other Subjects	1	0.77		1	1	
Geography and another subject	1	1	1		1	
NR	1	1	1	1		
Climate change impacts	**R: 95.39**	**R95.97**	**R: 103.2**	**R:147.9**	**R: 36.5**	**0.21**
Geography/Education		1	1	0.42	1	
Geography only	1		1	0.44	1	
Other Subjects	1	1		1	1	
Geography and another subject	0.42	0.44	1		**0.7**	
NR	1	1	1	1		
Climate change responses	**R:88.48**	**R: 108.35**	**R: 89.38**	**R: 82.5**	**R:162**	**0.11**
Geography/Education		0.22	1	1	1	
Geography only	0.22		1	1	1	
Other Subjects	1	1		1	1	
Geography and another subject	1	1	1		1	
NR	1	1	1	1		
CCS	**R:90.81**	**R:105.19**	**R:88.18**	**R: 113.6**	**R: 105**	**0.44**
Geography/Education		0.97	**1**	1	1	
Geography only	0.97	1	1	1	1	
Other Subjects	1	1		1	1	
Geography and another subject	1	1	1		1	
NR	1	1	1	1		

p ≤ 0.5 reject Ho. p > .05 accept Ho.

The data shown in Table 55 indicate that no significant difference was found between any two areas of specialisation in terms of literacy in climate change science following p-values of 0.42, 0.21 and 0.11 for climatic processes and causes of climate change, climate change impacts and climate change responses respectively. P-value for the total is 0.44, which is greater than 0.05. Hence, there is no significant difference in climate change science literacy due to teacher specialisation. The study therefore concludes that there is no significant difference in the distributions of the scores of the categories of specialisation on literacy in CCS.

4.6.6 Teaching experience

- Ho6: There are no significant differences in the distributions of the scores of teaching experience on literacy climate change science.

Table 56: Results of Mann-Whitney U Test on literacy in climate change science between the categories of teaching experience

Variable	**Teaching Experience**		**Ranked Sum >10yrs**	**Ranked Sum <10yrs**	**U**	**Z**	**P-value**
	>10yrs	**<10yrs**					
Processes and causes of climate change	158	35	15945.5	2775.5	2145.5	2.07	0.04
Climate change impacts	158	35	16062	2659	2029	2.46	**0.01**
Climate change responses	158	35	16016.5	2704.5	2074	2.31	**0.02**
CCS	158	35	16374	2347	1717	3.5	**0.00**

$p \leq 0.5$ reject Ho. $p > .05$ accept Ho.

The data in Table 56 show that the obtained p-value for climatic processes and causes of climate change of 0.04 is less than the critical p-value of 0.05; hence a significant difference exists between geography teachers aged over 40 years and those younger than 40 years on literacy in climatic processes and causes of climate change. The obtained p-value of 0.01 for climate change impact is less than 0.05; therefore a statistically significant difference was found between geography teachers with over 10 years of teaching experience and those with less than 10 years of teaching experience on literacy in climate change impacts. The obtained p-value of 0.02 on climate change responses is less than the critical value of 0.05; therefore a significant difference was also found between geography teachers with over 10 years of teaching experience and those with less than 10 years of teaching experience on literacy in climate change responses. On CCS as a whole, the obtained p-value of 0.00 is less than the critical value of 0.05; hence the study concludes that there is a significant difference in the distributions of the scores of teaching experience on literacy in CCS.

4.6.7 Grade Mostly Taught

- Ho7: There are no significant differences in the distributions of the scores of grades mostly on literacy in climate change science.

Table 57: Results of Mann-Whitney U Test on literacy in climate change science between the categories of grade mostly taught

Variable	Grade 10	Grade 11	Grade 12	Total p
Processes and causes of climate change	R:97.04	R:89.85	R:9976	
Grade 10		1	1	**0.67**
Grade 11	1		1	
Grade 12	1	1		
Climate change impacts	**R:86.6**	**R:86.17**	**R:104.21**	
Grade 10		1	0.36	**0.14**
Grade 11	1		0.35	
Grade 12	0.36	0.35		
Climate change responses	**R:78.76**	**R:93.52**	**R:107.28**	**0.01**
Grade 10		0.75	0.007	
Grade 11	0.75		0.7	
Grade 12	0.007	0.7		
CCS	**R:82.49**	**R:86.12**	**R:107.33**	
Grade 10		1	0.03	
Grade 11	1		0.23	**0.02**
Grade 12	0.03	1		

p ≤ 0.5 reject Ho. p > .05 accept Ho.

Table 57 shows that there is no significant difference in literacy in climatic processes and climate change impacts between the teachers based on the grades they mostly teach following the observed p-values of 0.67 and 0.14 respectively. However, a significant difference was found between them on climate change responses, as the observed p-value of 0.01 is less than the critical p-value of 0.05. A significant difference exists in CCS as a whole, as the observed p-value of 0.02 is less than the critical p-value of 0.05; hence Ho7 is accepted. There is no significant difference in the distributions of the scores of categories of grade mostly taught on literacy in CCS.

4.6.8 Experience in Providing Instruction on Climate Change

- Ho8: There are no significant differences in the distributions of the scores of the categories of experience in providing instruction on climate change on literacy in climate change science.

Table 58: Results of Mann-Whitney U Test on influence of experience in teaching climate change lessons on climate change science literacy

Variable	Experience in providing climate change instruction		Ranked Sum Yes	Ranked Sum No	U	Z	P-value
	Yes	No					
Processes and causes of climate change	183	11	17997	918	852	0.85	**0.39**
Climate change impacts	183	11	18103.5	811.5	745.5	1.44	**0.15**
Climate change responses	183	11	17852	1063	997	0.05	**0.96**
CCS	183	11	18082.5	832	766.5	1.32	**0.19**

$p \leq 0.5$ reject Ho. $p > .05$ accept Ho.

The data in Table 58 indicates that the obtained p-values on on the distribution of scores on climatic processes and causes of climate change (0.39), climate change impacts (0.15) and climate change responses (90.96) are greater than the critical p-value of 0.05. On climate change science as a whole, the observed p-value of 0.19 is also greater than the critical value of 0.05; hence Ho8 is rejected. Therefore, the data presented shows that there is no significant difference in the distributions of the scores of the categories of experience in teaching climate change concepts on literacy in CCS.

4.7 THE RESPONDENTS' SCORES ON CLIMATE CHANGE PEDAGOGICAL LITERACY

4.7.1 Level of Literacy in Climate Change Pedagogy

Table 59: Levels of literacy in climate change pedagogy

Variable	N	0-20 Very Low		21-40 Low		41-60 High		61-80 Very High		81-100 Excellent	
		N	%	N	%	n	%	n	%	N	%
Aims and significance of climate change education	194	23	11.9	85	43.81	36	18.56	38	19.59	11	5.67
Constructivist teaching principles	194	49	25.3	81	41.75	49	25.26	15	7.73	1	0.52
CCP	194	37	19.1	77	39.69	75	38.66	10	5.16	1	0.52

The data in Table 59 indicate that there are different levels of literacy in CCP among the participants of this study. On the aim and significance of climate change education, 11.9% demonstrated very low literacy; 43.81% demonstrated low literacy; 18.56% demonstrated high literacy; 19.59% demonstrated very high literacy; and 5.67% demonstrated excellent literacy. These figures indicate that the majority of the participants (43.81%) demonstrated low literacy of the aims and significance of climate change education. On constructivist teaching principles, 25.3% demonstrated very low literacy; 41.75% demonstrated low literacy; 25.26% demonstrated high literacy; 7.73% demonstrated very high literacy; and 0.52 demonstrated excellent literacy. On climate change pedagogy in general, 19.1% demonstrated very low literacy; 39.69% demonstrated low literacy; 38.66% demonstrated high literacy; 5.16% demonstrated very high literacy; and 0.52% demonstrated excellent literacy. These figures suggest that the majority of the participants (39.69%) demonstrated low literacy in CCP. Details of the respondents' performance on individual items in climate change pedagogy are presented in the histograms in Section 4.7.2

4.7.2 Frequency distribution of Responses to Climate Change Pedagogy Items

Sections 4.7.2.1 to 4.7.2.2 present the respondents' answers to items in the two domains of climate change pedagogy: aims and significance of climate change education, and constructivist teaching principles and practice.

4.7.2.1 Responses on aims and significance of climate change education

Question 1

Children are the most affected by climate change because

A. the population of children and young people is large
B. children have limited access to resources
C. most parents do not take proper action to protect their children
D. many children in schools lack discipline
Keyed option is B. Question is Conceptual. Weight is 2.

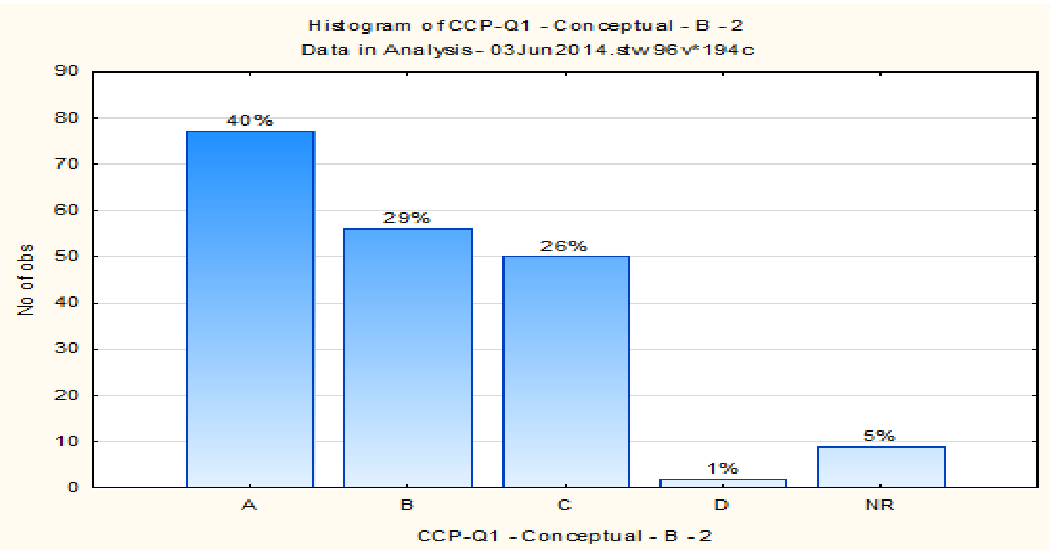

Figure 29: Histogram showing frequency and percentage of responses to CCP – Question 1

The data in Figure 29 indicate that when the participants were asked why children are the most affected by climate change, 40% responded that the population of children and young people is large; 29% responded that children have limited access to resources; 26% responded that most parents do not take proper action to protect their children; 1% responded that many children in schools lack discipline; and 5% did not respond to the question. With B as the keyed option, the majority (71%) of the participants did not know that children are the most affected by climate change because of their limited access to resources. Only 29% of them knew that children are the most affected by climate change because of their limited access to resources.

Question 2

Which of the options below is not an objective of climate change education?
A. Helping learners to understand the causes and effects of climate change.
B. Empowering learners to take actions that will help them to adapt to climate change.
C. Enabling learners to debate issues relating to climate change.
D. Empowering learners to decide on new policies on climate change
Question is Factual. Keyed option is D. Weight is 1.

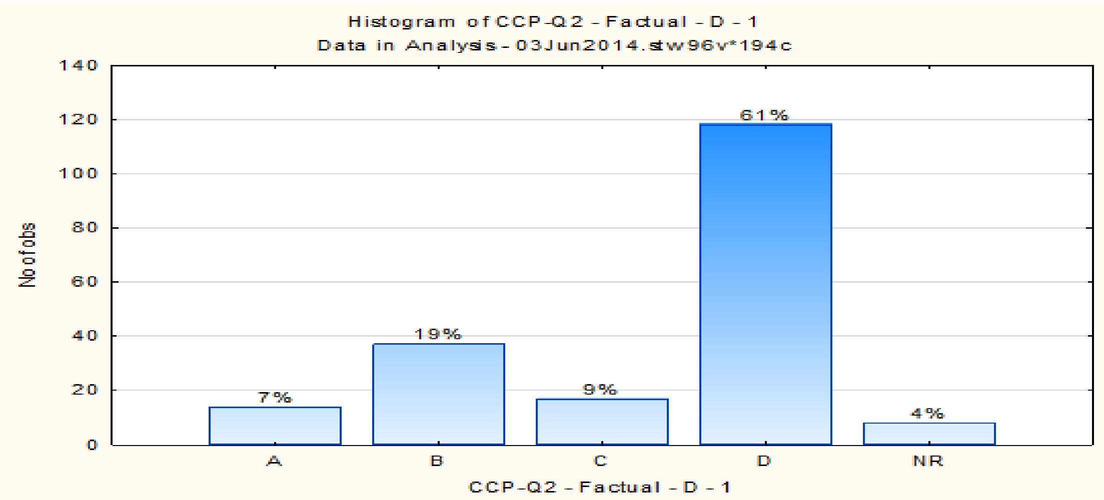

Figure 30: Histogram showing frequency and percentage of responses to CCP – Question 2

The data presented in Figure 30 show that, when the participants were asked to identify from a list of given options the one that is not an objective of climate change education, 7% responded ‘Helping learners to understand the causes and effects of climate change’; 19% responded ‘Empowering learners to take actions that will help them to adapt to climate change’; 9% responded ‘Enabling learners to debate issues relating to climate change'; 61% responded 'Empowering learners to decide on new policies on climate change'; and, 4% did not respond to the question. As D (Empowering learners to decide on new policies on climate change) was the keyed option, the majority (61%) of the FET Geography teachers that participated in this study understood that empowering learners to decide on new policies on climate change is not among the objectives of climate change education.

Question 3

Teaching learners that social equality in society can be achieved when natural resources are managed effectively will help them understand that

A. society, natural resources and development are connected
B. natural resources cannot be exhausted
C. society does not require natural resources to achieve social equality
D. development, society and natural resources are unrelated
Question is Conceptual. Keyed option is A. Weight is 2.

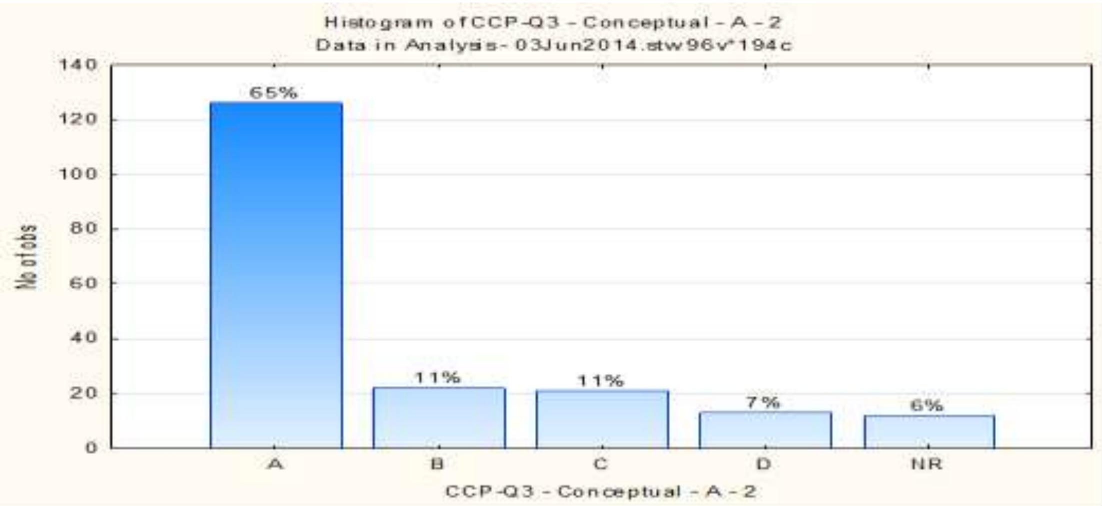

Figure 31: Histogram showing frequency and percentage of responses to CCP – Question 3

Figure 31 shows that the participants gave diverse responses to the question on teaching learners that social equality in society can be achieved when natural resources are managed effectively. A total of 65% responded that society, natural resources and development are connected; 11% responded that natural resources cannot be exhausted; 11% responded that society does not require natural resources to achieve social equality; 7% responded that development, society and natural resources are unrelated; and 6% did not respond to this item. With option A as the correct answer, the majority (65%) of FET Geography teachers who participated in this study understand that teaching learners that social equality in society can be achieved when natural resources are managed effectively will help them understand that society, natural resources and development are connected.

Question 4

One of the options below is not a mathematical skill needed for conducting climate change vulnerability analysis.

A. Inferential reasoning

B. Measurement

C. Identifying issues

D. Modelling

Question is Factual. Keyed option C. Weight is 1.

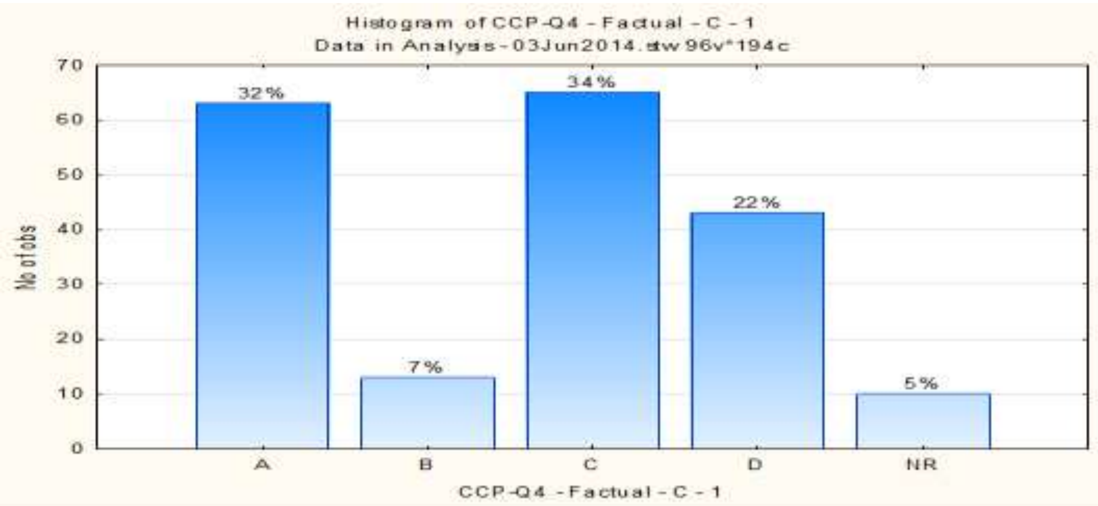

Figure 32: Histogram showing frequency and percentage of responses to CCP – Question 4

Figure 32 shows that, when the 194 participants in this study were asked to identify from a given list of options the one that is not a mathematical skill needed for conducting climate change vulnerability analysis, 32% stated ‘Inferential reasoning’;

7% stated 'Measurement'; 34% stated 'Identifying issues'; 22% stated 'Modelling'; and 5% did not respond to the question. Taking into account that option C is the correct answer, the study concludes that only 34% of FET Geography teachers that participated in this study understand that 'identifying issues' is not among the mathematical skills needed for conducting climate change vulnerability analysis.

Question 5

Assessing a variety of climate change adaptation options, choosing the best from among the options, and being aware of consequences of the choices that one makes are examples of

A. information processing
B. dialogic negotiation
C. knowledge construction
D. decision making

Question is Conceptual. Keyed option is D. Weight is 2.

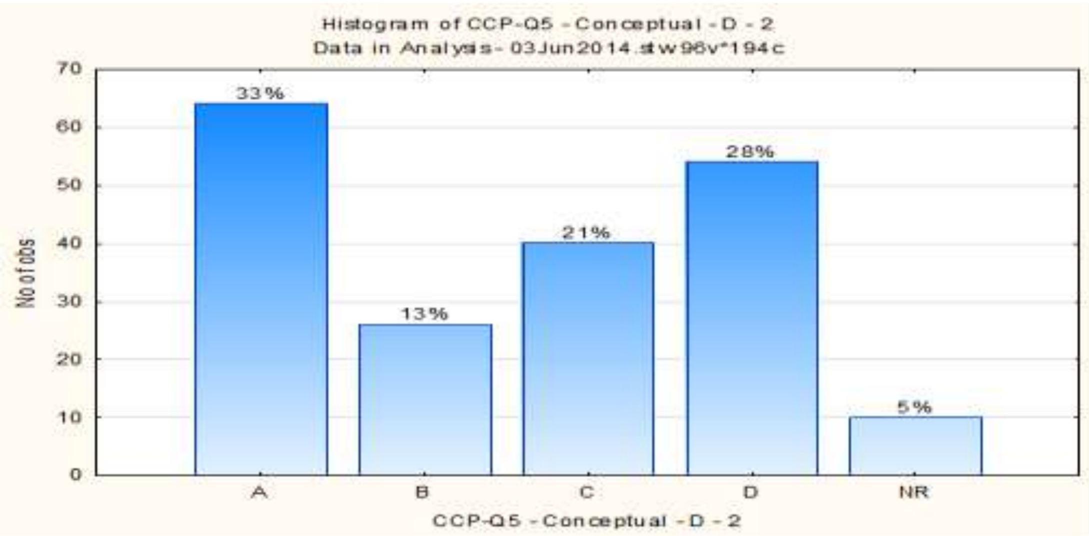

Figure 33: Histogram showing frequency and percentage of responses to CCP – Question 5

The data shown in Figure 33 shows that, of the 194 participants of the study, 33% chose option A - information processing; 13% chose option B - dialogic negotiation; 21% chose option C- knowledge construction; 28% chose option D - decision making; and 5% chose none of the options. Since the keyed option is D, the study it implies that only 28% of FET Geography teachers that took part in this study understood that assessing a variety of climate change adaptation options, choosing the best from among the options, and being aware of consequences of the choices that one makes are examples of decision-making.

4.7.2.2 Responses on constructivist teaching principles

Question 6

A learner read from a textbook that the global climate pattern is changing and humans are the main cause. Yet, this learner still doubts that there is enough proof in his or her location that requires taking immediate action. The situation that this learner finds him or herself is called

A. cognitive apprenticeship

B. cognitive autonomy

C. cognitive load

D. cognitive conflict

Question is Conceptual. Keyed option is D. Weight is 2.

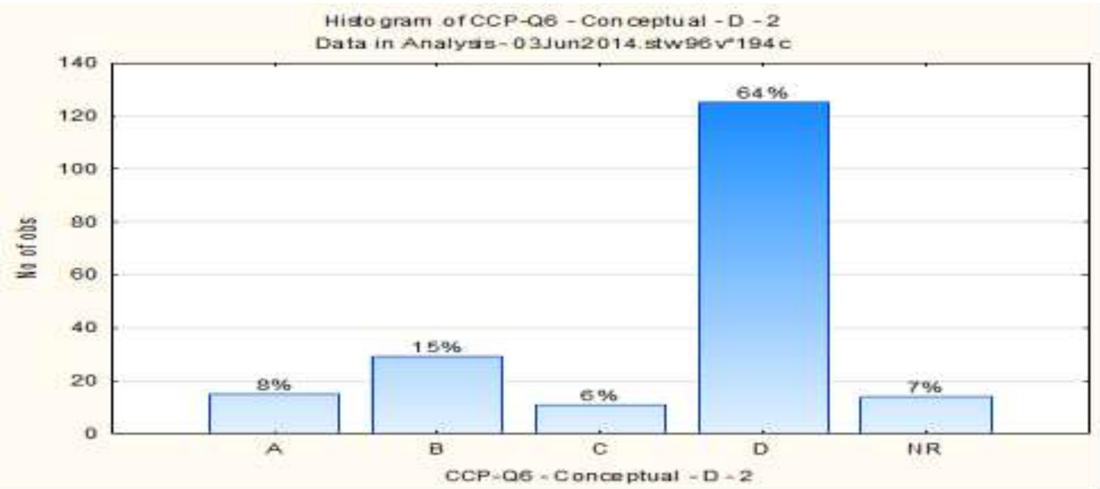

Figure 34: Histogram showing frequency and percentage of responses to CCP – Question 6

Figure 34 shows that 8% of the participants chose option A - cognitive apprenticeship; 15% of them chose option B - cognitive autonomy; 6% chose option C - cognitive load;

64% chose option D - cognitive conflict; and 7% did not choose any option. Considering that the correct option is D, the study concludes that the majority (64%) of the FET Geography teachers that took part in this study understood that the situation in which this learner finds him- or herself is called cognitive conflict.

Question 7

One of the teachers in your school often complains that some learners have difficulty in constructing their own ideas when learning new concepts relating to climate change. Which of these strategies should this teacher emphasise in future lessons?

A. Making judicious use of learning time

B. Completing tasks independently

C. Predicting the trends of future events

D. Thinking before providing answers to questions

Question is Procedural. Keyed option is C. Weight is 3.

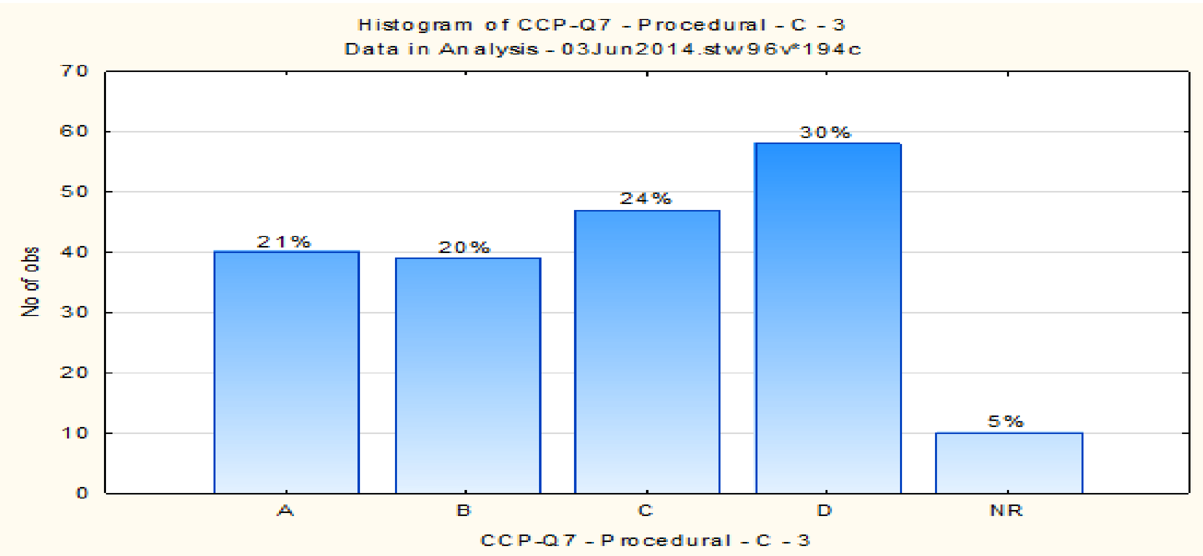

Figure 35: Histogram showing frequency and percentage of responses to CCP – Question 7

The data presented in Figure 35 shows that the participants hold diverse views about the strategies to deal with learners who experience difficulty in constructing new ideas. A total of 21% of them chose A - Making judicious use of learning time; 20% chose B - Completing tasks independently; 24% chose C - Predicting the trends of future events;

30% chose D - Thinking before providing answers to questions; and 5% of the participants did not respond to the question. With C - Predicting the trends of future events as the correct answer, only 24% (the minority) of the 194 FET Geography teachers understood that learners who have difficulty in constructing their own ideas when learning new concepts relating to climate change can be helped by encouraging them to predict trends of future events.

Question 8

A teacher often gives his or her learners tasks and conditions similar to those that they will meet later in their home environment. This teacher's effort is likely to promote

A. concept learning

B. cooperative learning

C. inquiry learning

D. transfer of learning

Question is Procedural. Keyed option is D. Weight is 3.

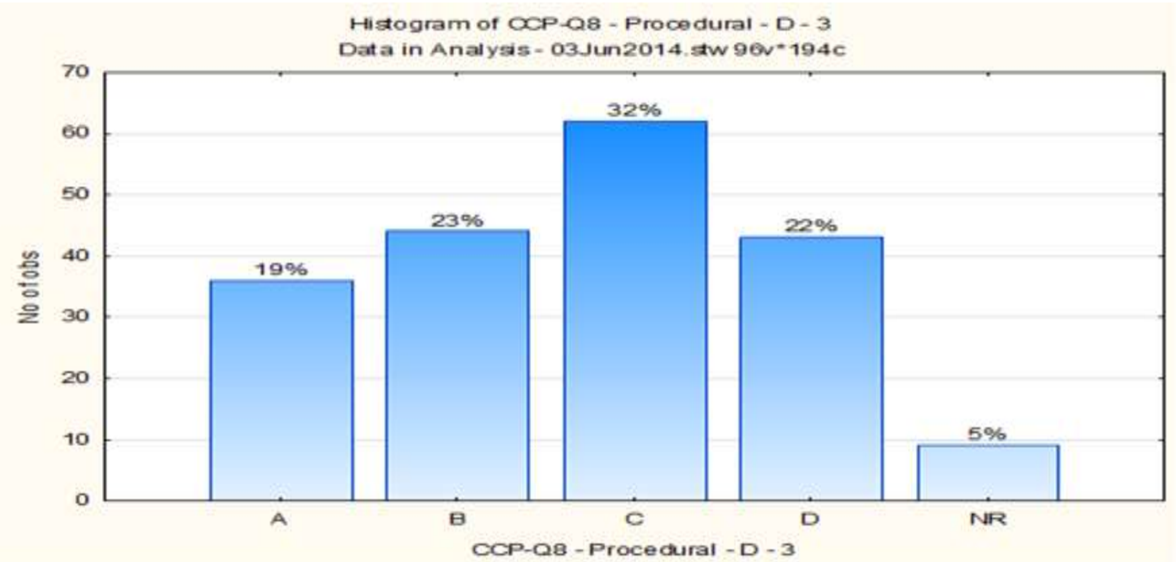

Figure 36: Histogram showing frequency and percentage of responses to CCP –8

Figure 36 shows that there were varied responses to Question 8. Out of 194 participants who took part in this study, 19% chose A - concept learning; 23% chose B - cooperative learning; 32% chose C - inquiry learning; 22% chose D - transfer of learning; and 5% of the participants did not respond to this question. Following that the keyed option is D - transfer of learning, the study concludes that only 22% of the FET Geography teachers understood that a teacher often gives his or her learners tasks and conditions similar to those that they will meet later in their home environment is likely to promote transfer of knowledge.

Question 9

Which of the sequences listed below can a teacher apply to change the faulty concepts learners hold about global warming?

A. Investigate, Transfer, Hypothesise, Review

B. Review, Hypothesise, Transfer, Investigate

C. Hypothesise, Investigate, Review, Transfer

D. Transfer, Review, Investigate, Hypothesize

Question is Procedural. Keyed option is C. Weight is 3.

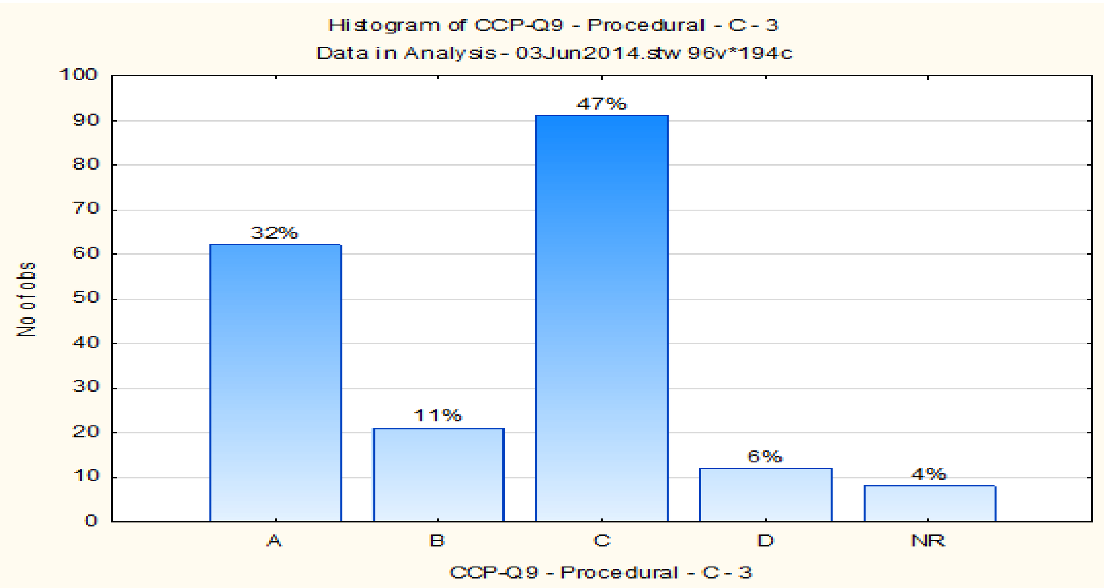

Figure 37: Histogram showing frequency and percentage of responses to CCP – Question 9

The data in Figure 37 show that 32% of the participants chose A - Investigate, Transfer, Hypothesise, Review; 11% chose B - Review, Hypothesise, Transfer, Investigate; 47% chose C - Hypothesise, Investigate, Review, Transfer; 6% chose

Transfer, Review, Investigate, Hypothesise; and 4% did not respond to this question. As C is the keyed option, only 47% of FET Geography teachers that took part in this study understood that a teacher applies instructions that focus on hypothesising, investigating, reviewing and transferring of ideas to change the faulty concepts learners hold about global warming.

Question 10

Some learners in a class performed poorly in previous assessments on the causes and effects of climate change. Which of these assessment forms provides the greatest opportunity for learners to close the gap in their understanding?

A. Diagnostic assessment
B. Summative assessment
C. Baseline assessment
D. Formative assessment
Question is Procedural. Keyed option D. Weight is 3.

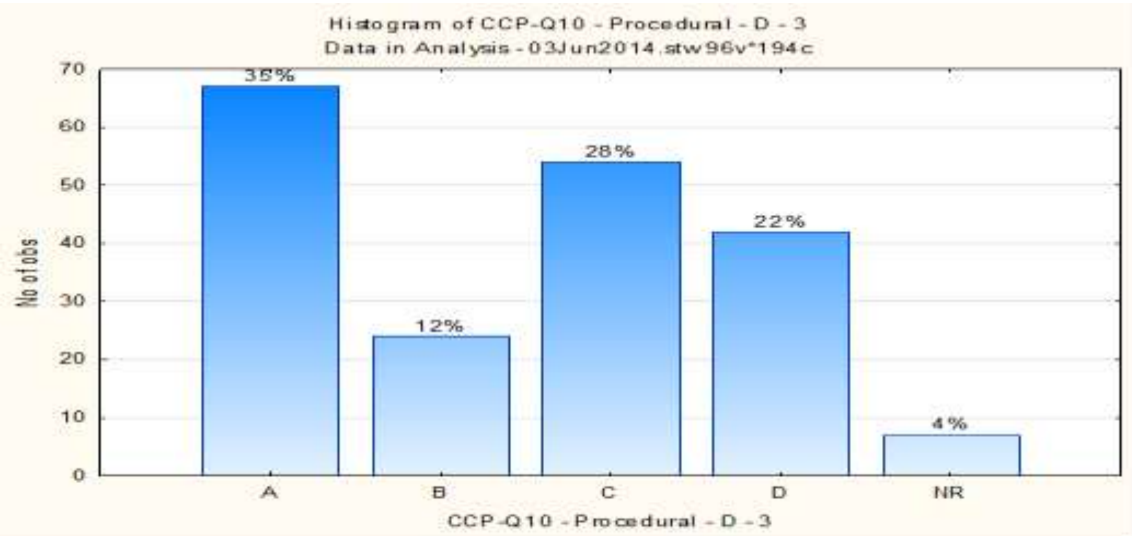

Figure 38: Histogram showing frequency and percentage of responses to CCP – Question 10

Figure 38 shows that 35% of the participants chose A - Diagnostic assessment; 12% chose B - Summative assessment; 28% chose C - Baseline assessment; 22% chose D - Formative assessment; and 4% did not respond to the question. On the grounds that the keyed option is D - Formative assessment, it is concluded that 78% of respondents understood that formative assessment provides the greatest opportunity for learners to close the gap in their understanding and of the causes and effects of climate change.

4.7.2.3 Misconceptions

Through the analysis of participants responses to the items in the CCPLQ, some deep misconceptions in climate change pedagogy were identified. Sixty-six per cent of the participants did not know that ability to identify issues is not a mathematical skills for conducting climate change vulnerability analysis. Seventy-two per cent of the participants did not know that the ability to assess a variety of climate change adaptation options, choosing the best from the list of options, and being aware of the consequences of the choices one makes refers to decision making. Over 75 per cent of the participants did not know that learners who have difficulty to construct their own ideas when learning new concepts relating to climate change can be helped with lessons that emphasise prediction of the trends of future events. Seventy-eight per cent of the participants did not know that transfer of learning can be promoted by giving learners tasks and conditions similar to those that they will meet later in their home environment. Over 50% of the participants do not that instructions that encourage formulation of hypothesis, investigation of problems, review of ideas and transfer of knowledge can enhance learners' ability to modify their misconception in a topic. Over 65% of the participants did not know that formative assessment provides a greatest opportunity than other forms of assessment in helping learners to close the gaps in their understanding of climate change.

4.8 THE HYPOTHESES ON CLIMATE CHANGE PEDAGOGICAL LITERACY

Like CCS, The hypotheses on CCP are based on data from the following variables:

- School location

- Gender
- Age
- Qualification
- Specialisation
- Teaching experience
- Grade mostly taught
- Experience in teaching lessons on climate change

4.8.1 School Location

- Ho1: There are no significant differences in the distributions of the scores of the categories of school location on literacy in climate change pedagogy.

Table 60: Results of Kruskal-Wallis tests of difference in literacy in climate change pedagogy between the categories of school location

Variable	Rural	Urban	Semi Urban	Total p
Aims and significance of climate change education	R:90.98	R:100.58	R88.93	0.46
Rural		1	1	
Urban	1		0.83	
Semi Urban	1	0.83		
Constructivist teaching principles	R:113.55	R:96.76	R:85.63	**0.31**
Rural		0.6	**0.42**	
Urban	0.6		**1**	
Semi Urban	**0.42**	**1**		
CCP	R:109.48	R:98.54	R:85.63	**0.29**
Rural		1	0.39	
Urban	1		**0.73**	
Semi Urban	0.39	**0.73**		

$p \leq 0.5$ reject Ho. $p > .05$ accept Ho.

Table 60 shows that no significant difference exists between geography teachers in terms of school location on the two variables of climate change pedagogical literacy, as the observed p-values of 0.46 and 0.31 for the aims and significance of climate change education, and constructivist teaching principles are greater than 0.05, which is the critical p-value. On the entire test, the observed value of 0.29 is also greater than the critical value of 0.05. Thus, no significant difference was found in the distributions of the scores of the categories of school location on literacy in CCP.

4.8.2 Gender

- Ho2: There are no significant differences in the distributions of the scores of the categories of gender on literacy in climate change pedagogy

Table 61: Results of Mann-Whitney U test of difference between categories of gender on literacy in climate change pedagogy

Variable	Gender		Ranked Sum Female	Ranked Sum Male	U	Z	P-value
	Female	Male					
Aims and significance of climate change education	87	107	8456	10459	4628	-0.07	**0.96**
Constructivist teaching principles	87	107	8264.5	10660	4436.5	-0.56	**0.58**
CCP	87	107	8217.5	16697	4389.5	-0.68	**0.5**

$p \leq 0.5$ reject Ho. $p > .05$ accept Ho.

Table 61 shows that the obtained p-value of 0.95 for the difference between the scores for Females and Males on Aims and Significance of Climate Change Education is greater than the critical p-value of 0.05. This implies that there is no significant difference between male and female Geography teachers on literacy in the aims and significance of climate change education. Similarly, no significant difference was found between male and female Geography teachers on literacy in constructivist teaching principles, considering that the obtained p-value of 0.58 is greater than 0.05. On climate change pedagogy, the calculated p-value of 0.5 is greater than the critical p-value of 0.05; hence, Ho1 is accepted: no significant difference was found in the distributions of the scores of categories of gender on literacy in CCP.

4.8.3 Age

- Ho3: There are no significant differences in the distributions of the scores of the categories of age on literacy in climate change pedagogy.

Table 62: Results of Mann-Whitney U test on age difference in climate change pedagogical literacy

Variable	Age		Ranked Sum <40	Ranked Sum >40	U	Z	P-value
	<40	>40					
Aims and significance of climate change education	38	155	3514.5	15206.5	2773.5	-0.55	**0.58**
Constructivist teaching principles	38	155	3569	15152	2828	-0.38	**0.71**
CCP	38	155	3524.5	15196.5	2783.5	-0.52	**0.6**

Table 62 shows that the obtained p-value on the aims and significance of climate change education is 0.58, which is greater than the critical p-value of 0.05; hence this study holds that there is no significant difference between Geography teachers aged less than 40 years and those aged more than 40 years on literacy in the aims and significance of climate change education. Similarly, the obtained p-value of 0.71 on constructivist teaching principle is greater than the critical p-value of 0.05; hence no significant difference was found between the two groups on literacy in constructivist teaching principles. On CCP as a whole, the obtained p-value of 0.6 is greater than critical p-value of 0.05. Therefore, the study concludes that no significant difference was found in the distributions of the scores of age on literacy in CCP.

4.8.4 Qualification

- Ho4: There are no significant differences in the distributions of the scores of the categories of qualification on literacy in climate change pedagogy.

Table 63: Results of Kruskal-Wallis test on difference between categories of qualification in literacy of climate change pedagogy

Variable	Masters	PG Dip	Bach	Hons.	Ord. Dip	NR	Total p
Aims and significance of climate change education	R:86.63	R:97.65	R:90.72	R:110.82	R:94.52	R:7.00	
Masters		1	1	1	1	1	**0.21**
PG Diploma	1		1	1	1	1	
Bachelor	1	1		**0.78**	1	1	
Honours	1	1	**0.78**		1	1	
Ordinary Diploma	1	1	1	1		1	
NR	1	1	1	1	1		
Constructivist teaching principles	R:99.88	R:94.18	R:96.69	R:106.46	R:89.55	R:10.5	
Masters		1	1	1	**1**	1	**0.46**
PG Diploma	1		1	1	**1**	1	
Bachelor	1	1		1	**1**	1	
Honours	1	1	1		**1**	1	
Ordinary Diploma	1	1	1	1		1	
NR	1	1	1	1	1		
CCP	R:100.38	R:93.01	R:92.00	R:112.27	R:91.19	R:3.5	
Masters		1	1	1	1	1	**0.17**
PG Diploma	1		1	1	1	1	
Bachelor	1	1		0.75	1	1	
Honours	1	1	0.75		**1**	**1**	
Ordinary Diploma	1	1	1	1		1	
NR	1	1	1	1	1		

p ≤ 0.5 reject Ho. p > .05 accept Ho.

The data in Table 63 show that no significant difference was found in the distributions of the scores of categories of qualification on literacy in climate change pedagogy, as the observed p-values of 0.21 and 0.46 for aims and significance of climate change education and constructivist teaching practice are greater than critical p-value of 0.05. On climate change education as a whole, Ho4 that states there are no significant differences in the distributions of the scores of the categories of qualification on literacy in climate change pedagogy is accepted. Hence, it is concluded that there is no significant difference between categories of qualification. This conclusion implies that the participants' literacy in CCP is not influenced by their qualifications.

4.8.5 Specialisation

- Ho5: There are no significant differences in the distributions of the scores of categories of specialisation on literacy in climate change pedagogy.

Table 64: Results of Kruskal-Wallis test on difference between the categories of specialisation on literacy in climate change pedagogy

Variable	Geo/Edu	Geo only	Others	Geo/another subject	NR	Total p
Aims and significance of climate change education	R:96.7	R:96.15	R110.15	R134.4	R:7.00	**0.18**
Geography/Education		1	1	1	1	
Geography only	1		1	1	1	
Other Subjects	1	1		1	0.73	
Geography and another subject	1	1	1		0.38	
NR	1	1	0.73	0.38		
Constructivist teaching principle	**R:90.12**	**R:106.85**	**R:91.68**	**R:101.7**	**R:10.5**	**0.15**
Geography/Education		0.58	1	1	1	
Geography only	0.58		1	1	0.88	
Other Subjects	1	1		1	1	
Geography and another subject	1	1	1		1	
NR	1	0.88	1	1		
CCP	**R:90.44**	**R:104.69**	**r:94.6**	**R:122.8**	**R:3.5**	**0.16**
Geography/Education		0.99	1	1	1	
Geography only	0.99		1	1	0.73	
Other Subjects	1	1		1	1	
Geography and another subject	1	1	1		0.52	
NR	1	1	1	0.52		

If p≤ 0.5, reject null hypothesis

Table 64 shows that observed p-value on literacy of the aims and significance of climate change education is 0.18, which is higher than critical p-value of 0.05. Hence, no statistical significant difference was found between the categories of specialisation on literacy in the aims and significance of climate change education. On constructivist teaching principles, a p-value of 0.15 was observed, which is also higher than the critical p-value of 0.05, prompting the rejection of the null hypothesis on this item. This rejection is an indication of no significant difference in the categories of specialisation on literacy in constructivist teaching principles. In total, a p-value of 0.16 was observed on literacy of climate change pedagogy between the categories of specialisation which is an indication of no significant difference in the distributions of the CCPL scores of the categories of specialisation. These results indicate that geography teachers' literacy in climate change pedagogy is not influenced by their specialisation.

4.8.6 Teaching Experience

- Ho6: There are no significant differences in the distributions of the scores of the categories of teaching experience on literacy in climate change pedagogy.

Table 65: Results of Mann-Whitney U test of differences in teaching experience literacy in climate change pedagogy

Variable	Teaching Experience		Ranked Sum >10yrs	Ranked Sum <10yrs	U	Z	P-value
	>10yrs	<10yrs					
Aims and significance of climate change education	158	35	16058.5	2662.5	2032.5	2.45	0.01
Constructivist teaching principles	158	35	15753.5	2967.5	2337.5	1.43	**0.15**
CCP	158	35	16101	2619.5	1989.5	2.59	**0.01**

$p \leq 0.5$ reject Ho. $p > .05$ accept Ho.

Table 65 shows that in terms of the aims and significance of climate change education, the observed p=value of 0.01 is less than the critical p-value of 0.05, resulting in the claim that there is a significant difference between teaching the teachers with less than ten years of experience in teaching and those with more than ten years of experience in teaching. In terms of constructivist teaching principles, observed p-value is 0.15 is greater than critical p-value of 0.05, resulting in the claim that there is no significant difference between teaching the teachers with less than ten years of experience in teaching and those with more than ten years of experience in teaching on literacy in constructivist teaching principles. In total, (climate change pedagogy), observed p-value is 0.01 whereas critical p-value is 0.05. Hence, it is concluded that there is a significant difference between teaching the teachers with less than ten years of experience in teaching and those with more than ten years of experience in teaching in terms of climate change pedagogy. These results indicate that geography teachers' literacy in CCP is influenced by their teaching experience.

4.8.7 Grade Mostly Taught

- Ho7: There are no significant differences in the distributions of the scores of grades mostly taught on literacy in climate change pedagogy.

Table 66: Results of Kruskal-Wallis test of difference the categories of grade mostly on literacy in climate change pedagogy

Variable	Grade 10	Grade 11	Grade 12	Total p
Aims and significance of CCE	R:94.22	R:82.17	R:81.93	**0.16**
Grade 10		1	1	
Grade 11	1		0.21	
Grade 12	1	0.21		
Constructivist teaching principles	**R:90.66**	**R:87.03**	**R:103.43**	**0.2**
Grade 10		1	0.52	
Grade 11	1		0.46	
Grade 12	0.52	0.46		
CCP	**R:92.59**	**R77.18**	**R:105.22**	**0.39**
Grade 10		0.69	0.53	
Grade 11	0.69		0.05	
Grade 12	0.54	0.05		

$p \leq 0.5$ reject Ho. $p > .05$ accept Ho.

The data in Table 66 shows that in terms of aims and significance of climate change education, no significant difference was observed between the categories of grade mostly taught. This claim is based on the fact that observed p-value of 0.16 is greater than critical p-value 0.05. Observed p-value of 0.2 for constructivist teaching principles is also greater than critical p-value of 0.05, resulting in the claim that there is no significant difference between the categories of grade mostly taught on literacy in climate change pedagogy. On CCP, observed p-value of 0.39 is greater than critical p-value of 0.05. Based on these figures, it is concluded that there is no significant difference between categories of grade mostly taught regarding literacy in climate change pedagogy. These results indicate that the participants' literacy in CCP is not influenced by the grades that they mostly teach.

4.8.8 Experience in Providing Instruction on Climate Change

- Ho8: There are no significant differences in the distributions of the scores of categories of experience in providing instruction on climate change on literacy in climate change pedagogy.

Table 67: Results of Mann-Whitney U test of difference between categories of experience in providing instruction on climate change on literacy in climate change pedagogy

Variable	Experience in providing climate change instruction		Ranked Sum Yes	Ranked Sum No	U	Z	P-value
	Yes	No					
Aims and significance of CCE	183	11	17921	994	928	0.43	**0.67**
Constructivist teaching principles	183	11	17747	1168	911	-0.53	**0.6**
CCP	183	11	17830.5	1084.5	994	-0.06	**0.95**

p ≤ 0.5 reject Ho. p > .05 accept Ho.

The data in Table 67 shows that the obtained p-value for aims and significance of climate change education is 0.67 which is greater than the critical p-value of 0.05. The figures indicate that there is no significance difference between categories of experience in providing instruction on climate change regarding literacy of aims and significance of CCE. Equally, observed p-value of 0.6 for constructivist teaching principles is greater than critical p-value of 0.05. These figures also show there is no statistical significance difference between categories of experience in providing instruction on climate change regarding literacy of constructivist teaching principles.

On climate change education in general, observed p-value of 0.95 is greater than critical p-value of 0.05, resulting in the claim that there is no significance difference between categories of experience in providing instruction on climate change regarding literacy of climate change education. These results indicate that the participants' literacy of CCP is not influenced by their experience in providing instruction on climate change.

4.9 SUMMARY OF THE RESULTS

This chapter presents and interprets the results of analysis of the data gathered from a sample of 194 participant representing 47.55% of the population of high school Geography teachers in the Western Cape. More than 90% of the participants responded to all the items. The results are summarised as follows:

a. The results of the analysis of data on school details

- Over 50% of the participants came from three urban districts: Metro East (44), Metro South (42) and Metro Central (39). The remaining five districts (one uran and 4 rural) contributed less than 50% of the participants.
- 139 out of 194 participants came from schools situated in urban areas, 34 from schools situated in semi-urban areas, and 21 from schools situated in rural areas.
- 186 out of the 194 participants, representing about 96% of the sample, came from mixed schools. Schools for only girls or boys contributed 3.09% and 1.03% of the sample respectively.
- 106 out of the 194 participants, representing 54.64%, came from schools with more than 1 000 learners, while 88 participants, representing 45.36% of the total participants, came from schools with less than 1 000 learners.
- Of the 194 participants of the study, 72 representing 37.11% came from schools with a population of less than 30 teachers, whereas 122 of the participants representing 62.89% came from schools with a teacher population of over 30.

- 89 out of the 194 participants representing 45.88% came from schools with two geography teachers; 73 of the participants representing 37.63% came from schools with more than two geography teachers; and 32 of participants representing 16.5% came from schools with one geography teacher.

b. The results of analysis of data on teacher details

- Of the 194 participants of the study 107 (55.16%) were men and 87 (44.85%) were women, which suggests that more male than female geography teachers participated in the study.
- 38 participants (19.59%) were younger than forty years of age, whereas 155 (79.9%) were older than 40 years. This suggests that the majority of geography teachers were over forty years of age.
- Of the 194 participants, 66 had Bachelor degree, 53 had with Honours degrees, 37 had a Postgraduate Diploma, 29 had Ordinary Diplomas, and eight had Master degree, which suggests that the majority had Bachelor degree.
- 83 participants (42.78%) studied Geography and Education, 85 participants (43.81%) studied Geography only, 5 participants (2.58%) studied Geography combined with another subject, and 20 participants (10.31%) studied other subjects that are not geography.
- 158 out of a total of 194 participants more than ten years of experience in teaching whereas 35 of the participants had less than ten years of teaching experience.
- 52 participants mainly taught Grade 10. Thirty participants taught mainly taught Grade 11, and one hundred and twelve participants (57.73%) taught mainly Grade 12.

  183 out of the 194 participants had taught lessons on climate change in the previous year. The rest had not taught lessons on climate change in the previous year.
- Out of the 194 participants in the study, 4 (2.06%) got the information they teach on CCS from workshops and seminars, (75) 38.66% got theirs from school textbooks, 79 (40.72%) got theirs from the Internet, 16 (8.25%) got

theirs from newspapers, and 6 (3.09%) got their information from television. The participants who got their information from peers and subject advisors made up 0.52% of the total, and those who got theirs from the radio made up 1.03% of the total. Eleven participants (5.67) did not indicate their sources of information on CCS.

- Furthermore, the participants got information on CCP from different sources, with 9.79% getting information from their peers and subject advisors, 14.43% from the Internet, 44.33% from school textbooks, 25.26% from workshops and seminars, and 0.52% from television. Eleven participants (5.67) did not indicate their sources of information on CCP.

c. Result of Instrument Reliability

Reliability of CCSLQ

- CCSLQ has reliability coefficient of 0.64 based on Cronbach’s test and 0.74 based on Guttman’s Split-half test.

Reliability of CCPLQ

- CCPLQ has reliability coefficient of 0.27 based on Cronbach’s test and 0.17 based on Guttman’s Split-half test.

Correlation coefficient of CCSL and CCPL scores

- A very low positive correlation (0.26) between the CCSL scores and the CCPL scores.

d. Level of Literacy in CCS

- The majority of the participants (45.88%) demonstrated very high literacy in CCS.
- 44.85% (the majority) demonstrating very high literacy in climatic processes and probable causes of climate change
- 29.38% (the majority) showed excellent literacy in climate change impacts
- 36.08% (the majority) demonstrated high literacy regarding climate change responses.

e. Key misconceptions in CCS

- 93% of the participants did not know that water vapour is the most abundant greenhouse gas and also the most important contributor to the natural greenhouse effect in the atmosphere
- 57% of the participants did not know that climate change science characterised by uncertainty;
- 92% of the participants believed that outbreak of diseases in developing countries is mainly due to climate change;
- 79% of the participants did not know the meaning of the term 'carbon sequestration;
- Only 34% of the participants understood that implementing guidelines to achieve carbon emission reduction targets is not a community-based adaptation to climate change

f. Hypotheses testing on the factors influencing CCSL

- A significant difference was observed in the distributions of CCSL scores by school location.
- A significant difference was observed in the distributions of CCSL scores by gender.
- A significant difference was observed in the distributions of CCSL scores by age.
- No significant difference was observed in the distributions of CCSL scores by qualification.
- N significant difference was observed in the distributions of CCSL scores by specialisation.
- A significant difference was observed in the distributions of CCSL scores by teaching experience.
- No significant difference was observed in the distributions of CCSL scores by of grade mostly taught.
- No significant difference was observed in the distributions of CCSL scores by experience in providing instruction on climate change.

g. Level of Literacy in CCP

- The majority of the participants (39.69%) demonstrated low literacy in CCP.
- 85 participants (43.81%), which is the majority, demonstrated low literacy in the aims and significance of CCE
- 81 participants (41.75%), which is the majority, demonstrated low literacy in constructivist teaching principles.

h. Key misconceptions in CCP

- 66% of the participants did not know that ability to identify issues is not a mathematical skills for conducting climate change vulnerability analysis.
- 72% of the participants did not know that the ability to assess a variety of climate change adaptation options, choosing the best from the list of options, and being aware of the consequences of the choices one makes refers to decision making.
- Over 75 per cent of the participants did not know that learners who have difficulty to construct their own ideas when learning new concepts relating to climate change can be helped with lessons that emphasise prediction of the trends of future events.
- 78% of the participants did not know that transfer of learning can be promoted by giving learners tasks and conditions similar to those that they will meet later in their home environment.
- Over 50% of the participants do not that instructions that encourage formulation of hypothesis, investigation of problems, review of ideas, and transfer of knowledge can enhance learners' ability to modify their misconception in a topic.
- Over 65% of the participants did not know that formative assessment provides a greatest opportunity than other forms of assessment in helping learners to close the gaps in their understanding of climate change.

i. Hypotheses testing on the factors influencing CCPL

- No significant difference was observed in the distributions of CCPL scores by school location.

- No significant difference was observed in the distributions of CCPL scores by gender.
- No significant difference was observed in the distributions of CCPL scores by age.
- No significant difference was observed in the distributions of CCPL scores by qualification.
- No significant difference was observed in the distributions of CCPL scores by specialisation.
- A significant difference was observed in the distributions of CCPL scores by years of experience in teaching.
- No significant was observed in the distributions of CCPL scores by grade mostly taught.
- No significance difference was observed in the distributions of CCPL scores by experience in facilitating instruction on climate change.

These results, including their implications, were discussed in Chapter 5

CHAPTER 5

DISCUSSION OF THE RESULTS, CONCLUSIONS AND RECOMMENDATIONS

This chapter analyses, interprets and synthesises the results from Chapter 4. Although the study involved gathering of data with a criterion-referenced instrument developed by the researcher, its main purpose was to determine how literate Geography teachers in the Western Cape Province are in climate change science and climate change pedagogy. The chapter is organised into sections: discussion of the results, the conclusions, the limitations, the implications, and the recommendations. The chapter ends with final statements by the researcher.

5.1 DISCUSSION OF THE RESULTS

The result of the analyses of observation of climate change science literacy of 194 Geography teachers in the Western Cape Province presented in Table 50 indicate very high literacy in climatic processes and probable causes of climate change, excellent literacy in climate change impact and high literacy in climate change responses. Overall, the data in Table 50 indicate that 152 of the respondents, representing 77.35%, demonstrated high literacy in climate change science. Considering that the sample for the study was 47.55% of the population of the FET band Geography teachers in the Western Cape, it could be generalised, on the basis of statistical evidence, that the majority of geography teachers in the Western Cape are literate in climate change science. These results corroborate those of Halder, Havu-Nuutinen, Pietarinen and Zyadin (2014) and Vujovic (2013) who found that geography teachers are fairly knowledgeable in climate change. However, the results contradict Ochienge and Koske (2013), Ambusaidi et al. (2012); Ekpo and Ekpo (2011); Lowther et al (2012); Nwankwo and Onachukwu (2012); Shepherdson et al (2011), Kilinc et al (2011); Ocal, Kisoglu, Alas and Gurbuz (2011); Liarakou, Athanasiadis and Gavrilakis (2011) and Boon (2010) who found teachers have poor knowledge of climate change.

The contradiction of the findings of the study with some of the results of previous studies is not surprising. The results presented in Tables 26 to 41 indicate that the majority of the respondents came from schools in three districts: 44 or 26.68% from Metropole East, 42 or 26.65% from Metropole South, and 30 or 20.1% from Metropole Central. These results indicate that about 70% of the respondents came from schools in urban districts. Table 51 provides an insight, indicating a statistically significant difference in observations on literacy in climate change science among the school location categories where *p*-value of 0004<0.05, resulting in the rejection of the null hypothesis. According to Bronfenbrenner (1993:39), within a given ecological setting are proximal processes that produce and sustain development, but their power to do so depend on the content and structure of the system. The fact that respondents from schools located in urban areas demonstrated high literacy in climate change science suggests that urban areas offer some unique opportunities for climate change education through the media, which rural areas may hardly offer. This gap should be considered in future policy on the development of climate change education, especially communication, education and awareness about climate change in rural areas.

All the respondents in the study were high school (FET phase) geography teachers, with 53 of them holding Honours degrees, 37 holding postgraduate diplomas, 29 holding ordinary diplomas, 66 holding Bachelor's degrees and eight holding Master's degrees. A total of 83 specialised in geography and education, 85 specialised in geography only and the rest specialised in other fields. This means that 168 out of the194 geography teachers who participated in this study held specialisation in geography. More than 90% of them had taught lessons on climate change in the previous year and their main source of information on climate change science was the Internet. Other sources from which they obtained information relating to climate change science included school textbooks, seminars and workshops, television, radio, newspapers and peers and subject advisors. This result is consistent with Liu et al. (2012), who found that teachers who had more access to information about climate change also had fewer misconceptions about climate change.

According to the United States Global Change Research Program (2009:3) people who are climate change literate demonstrate basic understanding of the climate system, including the natural and human-caused factors that affect it; they understand how climate observations and records as well as computer modelling contribute to scientific knowledge about the climate. They are aware of the fundamental relationship between climate and human life and the many ways in which climate has always played a role in human health. Even though people who are climate change literate may not be expected to demonstrate profound ability to assess the validity of scientific explanations about climate change, they should at least demonstrate the ability to access diverse scientific viewpoints about climate change, analyse the information that they have obtained and apply it in their decision-making.

Notwithstanding that the majority of geography teachers in the Western Cape demonstrated high literacy in climate change science, some of them demonstrated misconceptions about climate change. The results shown in Figures 16 to 30 indicate that, out of fifteen items that measured literacy in climate change science, the respondents had misconception on four. For example, 93% of the respondents did not know that water vapour is the most abundant greenhouse gas and also the most important contributor to the natural greenhouse effect in the atmosphere; 57% of them did not understand that climate change science is characterised by a measure of uncertainty; and 58% of them were of the opinion that poor service delivery in developing countries could not be the consequence of climate change. Further, only 31% of them understood that the term carbon sequestration means the removal of CO_2 from the atmosphere and depositing it in reservoirs. Only 34% of them (the minority) answered correctly that implementing guidelines to achieve carbon emission reduction targets is not a community-based adaptation to climate change. These misconceptions straddle the three subdomains of climate change science – climatic processes and probable causes of climate change, climate change impact and climate change responses. These findings corroborate Olufemi, Obianuju and Oyenike (2014) and Papadimitriou (2004), who found that teachers hold misconceptions about climate change.

The fact that geography teachers in the Western Cape demonstrated some misconceptions about climate change science could be the consequence of poor teacher education. Taking into account that the majority 155 (79.9%) of the geography teachers who participated in the study were over 40 years of age as indicated in Table 33, their misconceptions about climate change could be because they were trained many years earlier, when such issues were not on the global agenda, or because of their dependence on school textbooks for the information on climate change, as the data in Table 41 indicates. The issue of some teachers of geography who did not actually study geography, as indicated in Table 35, cannot be ignored. Teachers teach what they know. For, example, a teacher who studied management sciences and is employed to teach geography may not have adequate knowledge and understanding of climate change compared to a teacher who studied geography, notwithstanding how much access he or she has to the Internet and other electronic media sources of information about climate change. Some of these sources may not go deeper into global environmental issues that are associated with climate change, such as pollution, poverty and hunger, food insecurity, biodiversity degradation, ecosystem deterioration, water crises and land degradation. Knowledge of these issues is relevant for extending our understanding of the probable causes and impacts of climate change. This finding also highlights the need for teacher education in geography that is more issue-based.

The results of the analysis of data collected with the CCPLQ indicate that, out of the 194 geography teachers in the Western Cape who took part in the study, 114, representing 58.79%, demonstrated low literacy in climate change pedagogy, with the majority demonstrating low literacy in both the aims and significance of climate change education and constructivist teaching principles. These results are consistent with Lowther et al. (2012), Liu et al. (2012) and Nwankwo and Onachukwu (2012), who found that the majority of teachers perceive teaching climate change to their students as important, but many of them find teaching climate change concepts challenging. This view is evident from the findings that the majority of the respondents did not know that children are the most affected by climate change because of their limited access to resources; did not understand that assessing a variety of climate change adaptation options, choosing the best from among the options, and being aware of the consequences of the choices that one makes are examples of decision-making; and did not understand that learners who have difficulty in constructing their own ideas when learning new concepts relating to climate change can be helped by encouraging them to predict trends of future events. Further, they did not understand how transfer of knowledge can be applied in a climate change lesson and did not understand that the faulty concepts learners hold about global warming and climate change can be modified through instructions that promote hypothesis formulation, inquiry, review of meaning and transfer of knowledge. These findings corroborate Ergul (2013), who found that people form misconceptions in all subjects, but more commonly in subjects that involve complex concepts and contradictory explanations.

Several factors emerging from this study could explain geography teachers' low literacy in climate change pedagogy. Of the 194 geography teachers who participated in this study, only 83 specialised in geography and education. The others, who specialised in geography only and in non-geography disciplines, did not study pedagogy in their tertiary education. These teachers may not be familiar with implementing pedagogies that promote critical thinking and problem solving, which are relevant for the development of climate change literacy. The fact that 76.8% of the geography teachers who participated in this study taught geography to more than 50 learners at a time means that they might be grappling with the challenges of large class sizes, making it difficult to attend adequately to the specific needs of each student during instruction. The fact that the majority of the teachers (44.33%) got information on climate change pedagogy from school textbooks, rather than from workshops, seminars, peers and subject advisors, poses a serious challenge. This situation may have arisen from the fact that school textbooks are available and accessible as schools are supplied with books at the beginning of each school year.

By its nature, survey research makes generalisations based on data from a sample of the population; however, making generalisations in a context where the respondents came into the study with varying characteristics can be unfounded. In this study there was a statistically significant difference in literacy in climate change science among the respondents in relation to school location, gender, age and teaching experience. Conversely, no statistically significant difference was found in literacy in climate change science among the respondents in relation to their qualification, specialisation, grade mostly taught, and experience in teaching lessons on climate change. Pertaining to literacy in climate change pedagogy, it was found that a statistically significant difference existed with reference to teaching experience and grade mostly taught, whereas no statistically significant difference existed in terms of school location, gender, age, qualification, specialisation and experience in teaching lessons on climate change. It can be drawn from this account that teaching experience influences both teacher literacy in climate change science and teacher literacy in climate change pedagogy.

The results of the analysis of the data concerning the internal consistency of the observation of climate change science literacy and climate change pedagogical literacy, and the correlation between the observations (see Tables and 46 and Figure 15) indicate that the section of the instrument measuring climate change science literacy had internal consistency of 0.64 calculated with Cronbach's test and of 0.74 calculated with Guttman's test. Conversely, the section of the instrument measuring climate change pedagogical literacy had internal consistency of 0.27 obtained with the Cronbach's alpha test and 0.17 obtained with the Guttman's split-half test. A reliability value of 0.60 is an indication of average reliability and 0.70 and above is an indication of high reliability (Maiyaki and Mokhtar, 2011; Sekaran and Bougie, 2010). Reliability values less than 0.6 are unsatisfactory (Malhotra, 2004). For this study, the alphas of 0.64 and 0.74 for the section of the instrument measuring climate change science literacy are indications of good reliability, whereas 0.27 and 0.17 are indications of a low reliability. The correlation of 0.26 for the CCSL and CCPL score based on Spearman's test shown in Figure 15 suggests a very low positive correlation between the observations of the two main variables. This result suggests that an increase in the observation of climate change science literacy was not followed by a corresponding increase in the observation of climate change pedagogical literacy.

The extent to which the results presented in Chapter 4 could be upheld depends to a large extent on the degree of measurement error in the study. Such errors arise mainly from inappropriate sampling or samples that are not representative of the population. Measurement error can also arise from non-response. The results presented in Table 42 indicate that the 194 FET band geography teachers that participated in the study represented 47.55% of the population of geography teachers in the province. Although it was not possible for the researcher to obtain a complete list of geography teachers in the province, the figure quoted here was obtained from the eight curriculum advisors for geography. This number can be trusted because they were the ones working directly with geography teachers.

The data in Table 44 in Chapter 4 indicate that the 5.6% item non-response was the highest in Section 1 of the questionnaire, which focused on collecting data on school and teacher details. The items were those asking about sources of information on the science and pedagogy of climate change. Other items, with a 0.52% non-response rate, included gender, age, qualifications and specialisation. These items sought data that may be regarded as 'personal', which may explain the non-response to the items. In Sections 2 and 3, item non-response was as high as 11% and 5% in the observations of climate change science literacy and climate change pedagogical literacy, respectively (see Figures 20, 26, 34 and 38 in Chapter 4). Figure 20 was about the uncertainty of climate change science, Figure 26 shows the item about carbon sequestration, and Figure 34 is about the skills for conducting vulnerability analysis. Figure 30 is about strategies to promote transfer of knowledge in a climate change lesson. Based on these details, many of the non-responses were on items measuring climate change science. These gains may have arisen from the measures taken to the enhance response rate, such as making the questionnaire attractive in terms of its format, providing clear instructions, ensuring that the questionnaire is not lengthy and boring, constructing the questions in simple language, allowing the participants sufficient time to complete the questionnaire, and translating the questionnaire into languages spoken and written by the participants (see section 3.2.3.3.1 in Chapter 3).

The results of the measurement error indicate that a standard error mean of 0.25 was incurred. Standard error of the mean tells us how the mean varies with different measurements of the same variable. The data in Tables 44 and 47 indicates that the observed mean score for the sample on literacy in climate change science was 18.79, which is situated between the -95% and 95% confidence interval, with means of 18.09 and 19.5, respectively. Conversely, the observed mean score for the sample was 8.11, which is higher than the mean at the -95% confidence level and less than the mean at the 95% confidence level, with the lower limit as 7.61 and an upper limit of 8.62. These values suggest that there is high confidence in the results of this study on the basis of measurement error. This advantage may have been caused by the large sample used in the study.

5.2 LIMITATIONS OF THE STUDY

While the researcher claims that the research design for this study was fitting to achieve its purpose, some choices made by the researcher in the course of implementing the research design placed some restrictions on the conclusions. Referring to sections 1.2 and 1.3 of this dissertation, the two main concepts of the study are climate change science literacy and climate change pedagogical literacy. These two concepts are abstract or hypothetical. In an effort to locate the elements of these constructs and provide their operational meanings, the researcher undertook an extensive review of the literature on perspectives and models of literacy, science, pedagogy, and climate change and climate change education, culminating in the conceptual framework presented in Chapter 2. Based on the conceptual framework, three elements of climate change science and two elements of climate change pedagogy were located, leading to the formulation of three sub-questions derived from the main research question on climate change science literacy and two sub-research questions derived from the main research question on climate change pedagogical literacy. The study’s claim that constructivist teaching is the appropriate pedagogy for climate change obscures the fact that there could be other learner-centred teaching approaches that could be relevant to promote the development of climate change literacy in schools other than constructivist teaching approach.

The decision of the researcher to opt for a conceptual framework instead of a theoretical framework arose because of a lack of a single theory that adequately explains the nature of climate change science literacy and climate change pedagogical literacy and the methods of measuring them. Consequently, the researcher chose the integration of theories. Different theories of climate change science hold different assumptions. Although effort was made to ignore major differences, there was no guarantee that those differences had no influence on the choices of the elements included in the model of climate change science literacy and model of climate change pedagogical literacy. As a consequence, the elements used to define the constructs may not be exhaustive. This limitation could have been overcome by engaging in further review of the literature on models of climate change science and models of climate change pedagogy respectively.

Despite all the logically based choices made to produce a valid instrument and minimise measurement error, the CCPLQ still yielded scores with a very low internal consistency. None of the two main sections of the questions had an internal consistency that exceeded 0.7, which is the lower limit for good reliability. This pitfall could have been overcome by ensuring that a reliability of at least 0.7 was attained prior to data collection. However, it was not the main purpose of the study to develop reliable instruments for the measurement of climate change science literacy and climate change pedagogical literacy respectively; rather, the purpose of the study was to develop an assessment instrument that would help to determine the level of climate change science literacy and climate change pedagogical literacy of geography teachers in the Western Cape, including the factors influencing them.

Another limitation of the study arose from the researcher’s failure to select the sample by giving all the elements of the population equal chance to be included in the study. This would have been ideal considering the design of the study. But it was not possible for the researcher to obtain a complete list of all the FET geography teachers. In fact, such a list could not be obtained despite several requests and visits to the Provincial Department of Education. Even at that, selecting the participants based on a ready-made list could have resulted to the inclusion of participants who would not be eager to take part in the study. Their inclusion in the study would have compromised the response rate. To ensure that those eager to participate in the study were selected, the researcher adopted the ‘No Rule’ sampling technique, in which the individuals who were eager, available and accessible were selected for the study. Caution was also exercised to ensure that the eight education districts were represented in the sample, although their numbers varied. The violation of the assumption of random sampling limits the researcher’s ability to draw statistical inferences from the sample to the population. However, this limitation does not diminish the quality of the findings, so long as the sample size was large enough (47.55% of the entire population of high school geography teachers). I would advise anyone conducting similar research in the future to focus on a smaller area, like an education district or circuit, rather than covering a large area like a province.

The data gathered from the participants was subjected to a number of statistically valid analyses, presented and described in a systematic manner. However, failure to incorporate the qualitative approach in the study’s design particularly in the full-scale study obscures other ways in which teachers may respond to the questions asked and the answers provided in the full-scale study.

5.3 CONCLUSIONS

Despite the limitations of this study, particularly the reliability of CCPLQ, there are some noteworthy findings. It was found that geography teachers in the Western Cape are climate change science literate but not climate change pedagogy literate. Their literacy was mediated by a number of factors. It was found that school location, gender, age and teaching experience had a significant influence on their literacy in climate change science, whereas qualification, specialisation, grade mostly taught and experience in providing instruction on climate change had no significant influence on their literacy in climate change science. Pertaining to literacy regarding climate change pedagogy, it was found that teaching experience and grade mostly taught had a significant influence, whereas school location, gender, age, qualification, specialisation and experience in providing instruction on climate change had no significant influence. Notwithstanding that there were more influences on their literacy in climate change science than literacy in climate change pedagogy; the teachers still demonstrated a high level of literacy in climate change science. These findings suggest that there could be factors other than teaching experience and grade mostly taught that may explain the low level of literacy in climate change pedagogy demonstrated by Geography teachers in the Western Cape. The fact that the majority of the participants did not receive formal training in pedagogy could explain their low literacy in climate change pedagogy. Trusting that the assessment instrument used for gathering data in the study was valid to a reasonable extent, it is important that future research focuses on identifying other factors influencing Geography teachers' climate change pedagogical literacy.

The findings of this research project extend our understanding of the level of climate change pedagogical literacy of geography teachers in the Western Cape, and the factors influencing them. In addition, the CCSLQ and CCPLQ developed through this study may be significant and of value to prospective researchers in investigating teachers' climate change science literacy and climate change pedagogical literacy, if they could use the results of this study to improve the reliability of the questionnaires. The next section discusses the implications of the main findings of this study.

5.4 IMPLICATIONS OF THE RESULTS

Given the main findings of the study, it is important at this stage to discuss their implications in relation to theory, research, policy and practice of climate change education. One of the challenges facing research on the assessment of knowledge, understanding and capacity in relation to climate change science and climate change literacy was a lack of frameworks for understanding and measuring the constructs

(Pruneau et al., 2010; Læssøe et al., 2009; Lorenzoni and Pidgeon, 2006). To close this gap, the researcher developed a conceptual framework (see Chapter 2) through an extensive literature review. First, the subdomains of climate change science and climate change pedagogy were delineated. Following the conceptual framework, climate change science involves climatic processes and probable causes of climate change, climate change impacts and climate change solutions. Conversely, climate change pedagogy involves the aim and significance of climate change education, and constructivist teaching principles and practice.

Through the exposition of different theoretical perspectives of literacy, the researcher located three elements of literacy: knowledge, understanding and skill. These elements were integrated into the concept of climate change science and climate change pedagogy to derive the constructs 'climate change science literacy' and 'climate change pedagogical literacy' respectively. These two constructs are hypothetical but, based on the conceptual framework, they were operationally defined. Climate change science literacy refers to knowledge, understanding and capability regarding climatic processes and probable causes of climate change, climate change impacts and climate change responses. Individuals who are climate change science literate demonstrate knowledge and understanding of climatic processes and probable causes of climate change and climate change responses, and the capacity to mitigate and adapt to climate change. Conversely, climate change pedagogical literacy refers to knowledge, understanding and capacity regarding the aims and significance of climate change education and the principles and practice of constructivist teaching. Thus, individuals who are climate change pedagogically literate demonstrate knowledge and understanding of the aim and significance of climate change education and knowledge, and understanding and capacity to implement constructivist teaching in the classroom.

Except for Vujovic (2013), who studied geography teachers in South Africa, all previous research on the assessment of teacher knowledge and understanding of climate change and the methods of teaching content and concepts relating to climate change were conducted with samples from primary and secondary schools. Their participants were mainly in-service and pre-service secondary and primary teachers of different school subjects. None of the studies were high school geography teachers in the Western Cape. The present study chose a representative sample of geography teachers from high schools in the Western Cape. The Western Cape is one of the 'High' achieving provinces in terms of learner achievement. Other high achieving provinces in South Africa are Gauteng and the North-West province. Although the results of the study could not be generalised beyond the Western Cape, the outcomes may provide insight into the situation in other provinces with similar characteristics as the Western Cape in relation to literacy in climate change science and literacy in climate change pedagogy. These features enhance the ecological generalisability of the results.

Data for the study was collected with two criterion-referenced multiple-choice questionnaires developed by the researcher. The development of the questionnaires fulfilled the assumptions of measurement validity, including expert judgment, piloting and item analysis, and the assumptions of measurement reliability, including internal consistency of scores and marginal measurement error. These qualities gave the questionnaires the benefits of increased consistency of scoring and the possibility to facilitate valid judgment in the measurement of complex cognitive capabilities relating to climate change science and climate change pedagogy. The results of the correlation of the scores of climate change science literacy and climate change pedagogical literacy shows a low positive correlation between them. Low positive correlation implies that geography teachers who obtained high scores on literacy in climate change science obtained low scores on literacy in climate change pedagogy. The Cooperative Institute for Research in Environmental Education (CIRES, 2012) makes it clear that effective implementation of climate change education requires teachers who understand the science of climate change and the pedagogy to communicate this science to the learners.

Table 5 in Chapter 3 shows that over 80% of FET geography content topics were included in the content topics from which items for the CCSLQ were constructed. These content topics are conceptually underpinned by what is termed 'Geography's

Big Idea', namely place, spatial processes, spatial distribution patterns and human and environment interaction. These four 'Big Ideas' organise concepts that are central to thinking geographically and constructing geographical knowledge. The findings that the majority of geography teachers in the province demonstrated high literacy in climate change science gives some hope for climate change education, but mere knowledge of the content of climate change is insufficient to promote climate change literacy in schools. Their low literacy in constructivist teaching principles for climate change pedagogy might limit their capability to provide the kind of instruction that would cognitively inspire learners to make conceptual links and construct new knowledge when they are confronted with issues and problems that are geographical. With their low literacy of the aims and significance of climate change education, it is doubtful that they will be able to teach geography as if the planet matters.

Furthermore, the data in Table 35 in Chapter 4 indicates that 43.81% of the respondents had specialised in geography only, 42.78% had specialised in geography and education, 2.58% had specialised in geography combined with another subject, and 10.31% had specialised in other subjects besides Geography. Over 40% of the respondents were information on climate change pedagogy from school textbooks. This reliance on textbooks may be as a result of ageing teachers in schools, as the data in Table 33 indicates that 79.9% of the geography respondents were over the age of 40 years, which means that there are few younger geography teachers in our schools. Except if their age is matched with experience in digital technology, there could be notable generational gaps in the way geography teachers employ digital technologies for lesson planning, preparation and delivery, develop or share their work on websites, wikis or blogs, and engage in online discussions with learners, peers and mentors. Another age-related factor may be that most teachers received their teacher education when geography content topics did not include those that are linked to global warming and climate change.

5.5 RECOMMENDATIONS

The recommendations stated below are based on the findings of the study:

1. Considering that the majority of the geography teachers in the Western Cape demonstrated low literacy in climate change pedagogy and in the light of the concern about the quality of geography education they received, higher education institutions offering geography in teacher education should review their geography programmes to incorporate new climate change content topics and the relevant approaches and methods for teaching them.

2. On the basis that most of the geography teachers in the Western Cape studied geography only and some studied other subjects that have nothing to do with geography, it is recommended that the Department of Basic Education should come up with policies that will encourage teachers who are currently teaching geography in schools but do not hold qualifications in education to enrol for certificate or diploma courses in teaching so that they will acquire the relevant pedagogical skills to promote climate change literacy in schools.

3. Based on the result that indicates that most of the geography teachers in the Western Cape are over forty years of age and could have been taught with the traditional approach, it is recommends that District Education Departments should organise workshops, seminars and other professional development meetings for geography teachers on a regular basis to keep them abreast of problem-based learner-centred approach of teaching.

4. On the basis of the result that indicates geography teachers in the Western Cape obtain information about methods of teaching the concepts and content relating to climate change mainly from school textbooks and accompanying teacher guidelines, the Department of Basic Education should develop resource guides on methods of teaching lessons on climate change to guide the teachers in planning, preparation and delivery of lessons on climate change.

5.6 SUGGESTIONS FOR FURTHER RESEARCH

Based on the limitations of the study, the following suggestions for further research are made:

- Further research is required to extend the conceptual framework to incorporate more elements/variables for the assessment of climate change science literacy and climate change pedagogical literacy.
- Prospective researchers may consider investigating climate change science literacy and climate change pedagogical literacy of geography teachers in the Western Cape with mixed methods – combining the qualitative and the quantitative methods.
- Further research is required to fine-tune the CCSLQ and CCPLQ using the results of test of instrument reliability to produce a valid and more reliable instruments for assessing climate change science literacy and climate change pedagogical literacy.
- Further research is also required to assess the climate change science literacy and climate change pedagogical literacy of geography teachers in other provinces of South Africa that have similar characteristics as the Western Cape.

5.7. CONCLUDING STATEMENT

Completing this research project was a fulfilment of an inspiration that was ignited some years ago. Not only did this research project fulfil my curiosity to conduct a survey research project of a relatively wider scope, its outcomes may contribute to the extension of knowledge about the level of CCSL and the level of CCPL of Geography teachers in the Western Cape Province of South Africa, in addition to the factors influencing them.

At the conceptualisation phase of this research project, my initial idea was a comparative study of CCSL and CCPL of Geography teachers in the Republics of Seychelles and South Africa. My motivation to compare the two countries came from my experience as a teacher educator in both countries at different stages of my career. I still remember my supervisors, Professors Beet and Le Grange, tried to explain to me the implications of a comparative study of that breadth. Following further clarification I decided to trim the study down to its present scope – focusing on one province of South Africa. At a certain stage in the research process when the pressure started to build, I began to question myself why I did not concentrate on either climate change science literacy or climate change pedagogical literacy or a district in the Western Cape instead. It was then I realised that if I had continued with my earliest research proposal of a comparative study of CCSL and CCPL of Geography teachers in South Africa and the Seychelles, this research project would have experienced mortality.

Conducting this survey offered me a wealth of experience: I had the opportunity to understand the diversity of the Western Cape better, met colleagues from different cultural backgrounds, and built new professional relationships. One experience that will forever live with me is the support and enthusiasm the participants displayed during the process of data collection. Not one Geography teachers that I could reach refused to participate in the assessment: every one of them was excited to determine their level of literacy in climate change and their level of literacy in methods of facilitating climate change instruction. It was this excitement that produced the high response rate n the study. Furthermore, my interaction with the staff of the Statistical Consultation Unit in the data analysis phase of my study offered me a rewarding opportunity to learn new and quicker techniques of analysing data. If I had done the data analysis the way I knew it, it would have taken months more to produce the results of this research project.

The outcomes of this research project make clear that Geography teachers in the Western Cape have misconceptions about the science and pedagogy of climate change. Judging the opportunities, economic and cultural, that exist in the Western Cape, I have the feeling that the level of CCSL and CCPL of Geography teachers in provinces like the Eastern Cape and Limpopo might not be looking better. The situation could be worse in most of the districts and provinces in sub-Saharan Africa where resources are inadequate or poorly managed to initiate an efficient climate change education in schools. My view is that education about climate change should not be left in the hands of teachers alone; it must involve all citizens – policy makers, men and women in business, scientists, local communities, and civil organisations.

Besides informing the reader of this dissertation about the outcomes of this study, I also have a responsibility to communicate this message to the wider audience through seminars, workshops, informal discussions, and scholarly publications:

- The majority of high school Geography teachers in the Western Cape were in schools in urban areas, with most schools having more than 1000 learners and at least 2 Geography teachers.

- There were more male than female Geography teachers in high schools in the Western Cape, with the majority above the age of forty. The majority had Bachelor's degrees, but many of them specialised in Geography and had no formal training in pedagogy. The majority had more than ten years of experience in teaching, had taught lessons on climate change in the previous year, and got information on climate change science from the Internet and information on methods of teaching climate change concepts from school textbooks.

- The majority of Geography teachers in the Western Cape demonstrated very high literacy in CCSL. Some misconceptions were observed: the majority did not know that water vapour is the most abundant greenhouse gas and also the most important contributor to the natural greenhouse effect in the atmosphere; that climate change science is characterised by some uncertainty; and that the outbreak of diseases in developing countries is not mainly as a result of climate change. Furthermore, the majority did not know that the term 'carbon sequestration' refers to removal of carbon dioxide from the atmosphere and depositing it in reservoirs; and that implementing national guidelines targeting carbon emission reduction is not a community-based adaptation to climate change. Factors such as school location, gender, **age**, and experience in teaching had a significant influence on CCSL of Geography teachers in the

Western Cape; whereas factors such as qualification, specialisation, and experience in facilitating instruction on climate change, and the grade mostly taught, had no significant influence on the CCS literacy.

- The majority of Geography teachers in the Western Cape demonstrated low literacy in climate change pedagogical literacy, with profound misconceptions. The majority did not know that ability to identify issues is not a mathematical skills for conducting climate change vulnerability analysis; the ability to assess a variety of climate change adaptation options, choosing the best from the list of options, and being aware of the consequences of the choices one makes refers to decision making; learners who have difficulty to construct their own ideas when learning new concepts relating to climate change can be helped with lessons that emphasise prediction of the trends of future events. Furthermore, the majority did not know that the teacher can promote transfer of learning in the classroom by giving learners tasks and conditions similar to those that they will meet later in their home environment; instructions that encourage formulation of hypothesis, investigation of problems, review of ideas and transfer of knowledge can enhance learners' ability to modify their misconception in a topic; and formative assessment provides a greater opportunity than other forms of assessment in helping learners to close the gaps in their understanding of climate change.

- Factors such as school location, gender, age, qualification, specialisation, the grade mostly taught, and experience in facilitating climate change instruction had no significant influence on CCPL of Geography teachers, but years of experience in teaching had.

I hope this message will arouse thoughtful reflections among education policymakers, teacher educators, classroom teachers, researchers, and ordinary citizens on the challenges and prospect for climate change education in the Western Cape Province of South Africa.

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APPENDICES

Appendix 1: List of senior secondary schools in the Western Cape by district

SENIOR SECONDARY SCHOOLS IN WESTERN CAPE PROVINCE (TOTAL: 352)

METRO CENTRAL

1. Alexander Sinton Secondary School
2. Athlone Secondary School
3. Belgravia Secondary School
4. Bridgetown Secondary School
5. Camps Bay High School
6. Cape Town High School
7. Cathkin Secondary School
8. Crystal Secondary School
9. Gardens Commercial High School
10. Garlandale Secondary School
11. Good Hope Seminary High School
12. Groenvlei Secondary School
13. Groote Schuur High School
14. Harold Cressy High School
15. Heideveld Secondary School
16. Ikamvalethu Secondary School
17. Isilimela Secondary School
18. Jan van Riebeeck High School
19. Kensington Secondary School
20. Kulani Secondary School
21. Langa Secondary School
22. Livingstone High School
23. Maitland Secondary School
24. Manenberg Secondary School
25. Mount View Secondary School
26. Ned Doman High School
27. Oaklands Secondary School
28. Oude Molen Technical High School
29. Peak View Secondary School
30. Phoenix Secondary School
31. Pinelands High School
32. Queen's Park High School (Cape Town)
33. Rhodes High School
34. Rondebosch Boys' High School
35. Rustenburg Girls' High School
36. Rylands High School
37. Salt River Secondary School
38. Sans Souci Girls' High School
39. Sea Point High School
40. Silverstream Secondary School
41. South African College High School
42. Spes Bona High School
43. Thandokhulu Secondary School
44. Trafalgar Secondary School
45. Vista High School
46. Voortrekker High School
47. Westerford High School
48. Windermere Secondary School
49. Windsor High School
50. Zonnebloem Nest Senior School

METRO SOUTH

1. Aloe Secondary School
2. Beacon Hill Secondary School
3. Bergvliet High School
4. Cedar Secondary School
5. Crestway Secondary School
6. Dr. Nelson R. Mandela High School
7. Fairmount Secondary School
8. Fezeka Secondary School
9. Fish Hoek High School
10. Glendale Secondary School
11. Grassdale High School
12. Grassy Park Secondary School
13. Heathfield High School
14. Hout Bay Secondary School
15. I. D. Mkize Senior Secondary School
16. Immaculata Secondary School
17. Intsebenziswano Secondary School
18. Intshukumo Secondary School
19. Lavender Hill Secondary School
20. Lentegeur Secondary School
21. Lotus Secondary School
22. Masiphumelele High School
23. Mondale High School
24. Muizenberg High School
25. New Eisleben Secondary School
26. Norman Henshilwood High School
27. Ocean View Secondary School
28. Oscar Mpetha High School
29. Oval North Secondary School
30. Pelican Park High School
31. Phakama Secondary School
32. Phandulwazi High School
33. Phillipi Secondary School
34. Plumstead High School
35. Portland Secondary School
36. Princeton Secondary School
37. Rocklands Secondary School
38. Sibelius High School
39. Simon's Town School
40. Sinethemba Secondary School
41. Sithembele Matiso Secondary School
42. Sophumelela Secondary School
43. South Peninsula High School
44. Spine Road Secondary School
45. Steenberg Secondary School
46. Strandfontein Secondary School
47. Tafelsig Secondary School
48. Vuyiseka Secondary School
49. Westridge Secondary School
50. Wittebome High School
51. Woodlands Secondary School
52. Wynberg Boys' High School
53. Wynberg Girls' High School
54. Wynberg Secondary School
55. Zeekoevlei Secondary School
56. Zisukhanyo Secondary School
57. Zwaanswyk High School

METRO NORTH

1. Arcadia Senior Secondary School
2. Atlantis Secondary School
3. Beauvallon Secondary School
4. Belhar Secondary School
5. Bellville High School
6. Bellville-South Secondary School
7. Bellville Technical High School
8. Bishop Lavis Secondary School
9. Bloubergrant Secondary School
10. Bonteheuwel Secondary School
11. Bosmansdam High School
12. Buren High School
13. Cravenby Secondary School
14. D.F. Malan High School
15. Durbanville High School
16. Edgemead High School
17. Elsiesrivier Secondary School
18. Elswood Secondary School
19. Excelsior Secondary School
20. Fairbairn College
21. Fairmont High School
22. Florida Secondary School
23. Goodwood College
24. Inkwenkwezi Secondary School
25. J.G. Meiring High School
26. John Ramsay Secondary School
27. Kasselsvlei Comprehensive High School
28. Leiden Secondary School
29. Marian Secondary School
30. Masibambisane Secondary School
31. Mfuleni Secondary School
32. Milnerton High School
33. Modderdam Secondary School
34. Parow High School
35. Perseverance Secondary School
36. President High School
37. Proteus Secondary School
38. Range Secondary School
39. Ravensmead Secondary School
40. Robinvale High School
41. Rosendaal Secondary School
42. Saxonsea Secondary School
43. Simunye Secondary School
44. Sinenjongo High School
45. St. Andrew's Secondary School
46. Stellenberg High School
47. Symphony Secondary School
48. Table View High School
49. The Settlers High School
50. Tygerberg High School
51. Uitzig Secondary School
52. Valhalla Secondary School
53. Voorbrug Secondary School

METRO EAST

1. Bernadino Heights Secondary School
2. Blackheath Secondary School
3. Bloekombos Secondary School
4. Brackenfell High School
5. Bulumko Secondary School
6. Chris Hani Secondary School
7. De Kuilen High School
8. Eben Donges High School
9. Eersterivier Secondary School
10. Esangweni Secondary School
11. Forest Heights High School
12. Gordon Secondary School
13. Harry Gwala Secondary School
14. Hector Peterson Secondary School
15. Hottentots Holland High School
16. Intlanganiso Secondary School
17. Iqhayiya Secondary School
18. Joe Slovo Secondary School
19. Khanyolwethu Secondary School
20. Khayelitsha No. 1 Senior Secondary School
21. Kleinvlei Secondary School
22. Kuils River Technical Secondary School
23. Kwamfundo Secondary School
24. Luhlaza Secondary School
25. Macassar Secondary School
26. Malibu Secondary School
27. Manyano High School
28. Masibambane Secondary School
29. Masiyile Senior Secondary School
30. Matthew Goniwe Memorial High School
31. Monument Park High School
32. Parel Vallei High School
33. Rusthof Secondary School
34. Sarepta Secondary School
35. Scottsdene Secondary School
36. Scottsville Secondary School
37. Silversands Secondary School
38. Simanyene Secondary School
39. Siphamandla Secondary School
40. Sizimisele Secondary School
41. Strand High School
42. Strand Secondary School
43. Thembelihle High School
44. Tuscany Glen Secondary School
45. Usasazo Secondary School
46. Uxolo High School
47. Wallacedene Secondary School
48. Wesbank Secondary School
49. Zandvliet High School
50. Zola Senior Secondary School

WEST COAST

1. Augsburg Agricultural Gymnasium
2. Citrusdal High School
3. Clanwilliam Secondary School
4. Diazville High School
5. Dirkie Uys High School
6. Graafwater High School
7. Hopefield High School
8. Lutzville High School
9. Naphakade Secondary School
10. Nuwerus High School
11. Piketberg High School
12. Porterville High School
13. Schoonspruit Secondary School
14. Smuts-Malan High School
15. Steynville Secondary School
16. Swartland High School
17. Vanrhynsdorp High School
18. Velddrif High School
19. Vredenburg High School
20. Vredendal High School
21. Vredendal Secondary School
22. Wesbank Secondary School
23. Weston Secondary School

CAPE WINELANDS

1. Ashton Public Combined School
2. Ashton Secondary School
3. Bella Vista High School
4. Berg River Secondary School
5. Bloemhof High School
6. Boland Agricultural School
7. Bonnievale High School
8. Breë River High School
9. Ceres Secondary School
10. Charleston Hill Secondary School
11. Charlie Hofmeyr High School
12. Cloetesville High School
13. De Kruine Secondary School
14. Desmond Mpilo Tutu Secondary School
15. Drostdy Technical High School
16. Esselenpark Secondary School
17. Franschhoek High School
18. Goudini High School
19. Groendal Secondary School
20. Hex Valley High School
21. Hex Valley Secondary School
22. Hugenote High School
23. Iingcinga Zethu Secondary School
24. Kayamandi Secondary School
25. Klein Nederburg Secondary School
26. Kylemore Secondary School
27. Labori High School
28. La Rochelle Girls' High School
29. Langeberg Secondary School
30. Luckhoff Secondary School
31. Makupula Secondary School
32. Masakheke Combined School
33. Montagu High School
34. Montana High School
35. New Orleans Secondary School
36. Noorder-Paarl Secondary School
37. Paarl Gimnasium
38. Paarl Boys' High School
39. Paarl Girls' High School
40. Paul Roos Gymnasium
41. Paulus Joubert Secondary School
42. Rhenish Girls' High School
43. Robertson High School
44. Roodezandt Secondary School
45. Skurweberg Secondary School
46. Stellenbosch High School
47. Stellenzicht Secondary School
48. Tulbagh High School
49. Van Cutsem Combined School
50. Vusisizwe Secondary School
51. Waveren High School
52. Wellington Secondary School
53. Weltevrede Secondary School
54. Wolseley Secondary School
55. Worcester Gimnasium
56. Worcester Secondary School

OVERBERG

1. Albert Myburgh Secondary School
2. Barrydale High School
3. Bredasdorp High School
4. De Rust Futura Academy
5. De Villiers Graaff High School
6. Emil Weder Secondary School
7. Grabouw High School
8. Groenberg Secondary School
9. Hawston Secondary School
10. Hermanus High School
11. Napier High School
12. Overberg High School
13. Qhayiya Secondary School
14. Riviersonderend High School
15. Swartberg Secondary School
16. Swellendam High School
17. Swellendam Secondary School
18. Villiersdorp Secondary School

EDEN AND CENTRAL KAROO

1. Albertinia High School
2. Aurial College
3. Bastiaanse Secondary School
4. Beaufort West Secondary School
5. Bridgton Secondary School
6. Calitzdorp High School
7. De Rust Secondary School
8. Dysselsdorp Secondary School
9. Fezekile Secondary School
10. George Secondary School
11. Gerrit du Plessis Secondary School
12. Groot Brak River Secondary School
13. Haarlem Secondary School
14. Heidelberg High School
15. Hillcrest Secondary School
16. Imizamo Yethu Secondary School
17. Indwe Secondary School
18. Kairos Secondary School
19. Knysna High School
20. Knysna Secondary School
21. Ladismith High School
22. Ladismith Secondary School
23. Laingsburg High School
24. Langenhoven Gimnasium
25. Langenhoven High School
26. Mandlenkosi Secondary School
27. Morester Secondary School
28. Murray High School
29. Murraysburg High School
30. Oakdale Agricultural School
31. Oudtshoorn High School
32. Outeniqua High School
33. Pacaltsdorp Secondary School
34. Parkdene Secondary School
35. Percy Mdala High School
36. Plettenberg Bay Secondary School
37. Punt Secondary School
38. P.W. Botha College
39. Sao Bras Secondary School
40. Sentraal High School
41. Thembalethu Secondary School
42. Uniondale High School
43. Wittedrift High School
44. York High School
45. Zwartberg High School

Appendix 2: A Copy of the Ethical Clearance Notification

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY

Approval Notice
New Application

30-Sep-2013
Anyanwu, Raymond N

Proposal #: DESC_Anyanwu2013

Title: **AN ASSESSMENT OF CLIMATE CHANGE SCIENCE LITERACY AND CLIMATE CHANGE PEDAGOGY LITERACY OF GEOGRAPHY TEACHERS IN THE WESTERN CAPE PROVINCE**

Dear Dr Raymond Anyanwu,

Your DESC approved **New Application** received on **27-Aug-2013**, was reviewed by members of the **Research Ethics Committee: Human Research (Humanities)** via Expedited review procedures on **27-Sep-2013** and was approved.

Please note the following information about your approved research proposal:

Proposal Approval Period: **27-Sep-2013 -26-Sep-2014**

Please take note of the general Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

Please remember to use your **proposal number** (**DESC_Anyanwu2013**) on any documents or correspondence with the REC concerning your research proposal.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Also note that a progress report should be submitted to the Committee before the approval period has expired if a continuation is required. The Committee will then consider the continuation of the project for a further year (if necessary).

This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki and the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health). Annually a number of projects may be selected randomly for an external audit.

National Health Research Ethics Committee (NHREC) registration number REC-050411-032.

We wish you the best as you conduct your research.

If you have any questions or need further help, please contact the REC office at 0218839027.

Included Documents:
DESC form
Informed consent form
Research proposal
Permission letter

"IT IS HEREBY CERTIFIED THAT THIS IS A TRUE COPY OF THE ORIGINAL DOCUREMENT AND THAT THERE IS NO INDICATION THAT ALTERATIONS HAVE BEEN MADE THERETO BY AN UNAUTHORISED PERSON"
NAME ... RANK ... OFFICE ...
SIGNATURE ... DATE 2013 10 07

SA POST OFFICE STELLENBOSCH
07 OCT 2013

Sincerely,

Susara Oberholzer
REC Coordinator
Research Ethics Committee: Human Research (Humanities)

Appendix 3: A Copy of Approval of Access to Schools

Western Cape Government
Education

Directorate: Research

Audrey.wyngaard2@pgwc.gov.za
tel: +27 021 467 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20130805-15285
ENQUIRIES: Dr A T Wyngaard

"IT IS HEREBY CERTIFIED THAT THIS IS A TRUE COPY OF THE ORIGINAL DOCUMENT AND THAT THERE IS NO INDICATION THAT ALTERATIONS HAVE BEEN MADE THERETO BY AN UNAUTHORISED PERSON"
NAME ...... RANK ...... OFFICE ......
SIGNATURE ...... DATE 2013 10 07

SA POST OFFICE
STELLENBOSCH
07 OCT 2013
FOLIO

Dr Raymond Anyanwu
Flat 3, Villa Centre
Andringa Street
Stellenbosch
7600

Dear Dr Raymond Anyanwu

RESEARCH PROPOSAL: AN ASSESSMENT OF CLIMATE CHANGE SCIENCE LITERACY AND CLIMATE CHANGE PEDAGOGICAL LITERACY OF GEOGRAPHY TEACHERS IN THE WESTERN CAPE PROVINCE

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Approval for projects should be conveyed to the District Director of the schools where the project will be conducted.
5. Educators' programmes are not to be interrupted.
6. The Study is to be conducted from **01 September 2013 till 01 September 2014**
7. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
8. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
9. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
10. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
11. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
12. The Department receives a copy of the completed report/dissertation/thesis addressed to:
    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
Directorate: Research
DATE: 05 August 2013

Lower Parliament Street, Cape Town, 8001
tel: +27 21 467 9272 fax: 0865902282
Safe Schools: 0800 45 46 47

Private Bag X9114, Cape Town, 8000
Employment and salary enquiries: 0861 92 33 22
www.westerncape.gov.za

Appendix 4: A Copy of the Consent Form (in English)

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY

CONSENT TO PARTICIPATE IN RESEARCH

AN ASSESSMENT OF CLIMATE CHANGE SCIENCE LITERACY AND CLIMATE CHANGE PEDAGOGY LITERACY OF GEOGRAPHY TEACHERSIN THE WESTERN CAPE PROVINCE

You are asked to participate in a research study conducted by: **Dr. Raymond Ndubisi Anyanwu: D. Ed (UNISA), M. Ed (Port Harcourt), B.Sc. Ed (UNN), from the Department of Curriculum Studies, Faculty of Education, Stellenbosch University**. The results will contribute to the writing of a PhD dissertation and the publishing of scholarly research papers. You were selected as a possible participant in the study because of your status as a geography teacher in Western Cape, where the study is conducted.

1. PURPOSE OF THE STUDY

The purpose of the study is to measure the extent to which geography teachers are literate of climate change science and climate change pedagogy.

2. PROCEDURES

If you volunteer to participate in this study, we would ask you to:

i. complete a questionnaire which is scheduled to last for 30 minutes.
ii. provide some background details about yourself and your school and
iii. answer a set of multiple choice questions on climate change science and climate change pedagogy.

3. POTENTIAL RISKS AND DISCOMFORTS

There is no foreseeable risk for your participation in the study.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

Your participation in the assessment has immense benefit for your professional development. You may gain new knowledge about climate change and stimulate ideas about the teaching of climate change. The outcomes of the study promises to enhance the education community's understanding of the literacy of geography teachers in the Western Cape Province about climate change and the teaching of climate change and in so doing can be used for future research into geography teachers' literacy of climate change science and climate change pedagogy in other contexts.

5. PAYMENT FOR PARTICIPATION

Participation in the assessment is both voluntary and free. As a result there will be no payment, both financially and in kind, for your participation.

6. CONFIDENTIALITY

Any information that is obtained from you in the questionnaire will remain confidential and will be disclosed only with your permission or as required by law. To ensure confidentiality in the study, your name or that of the school will not be mentioned (it is not required in the questionnaire). Reference to your scores on the assessment will be made only to the generated number on the questionnaire. All data will remain in password-protected files that only I and my supervisors have access to.

1

When the study is completed, findings will be published in local and international journals, and presented at local and international conferences including other platforms for intellectual discourse on climate change education. New insights from the study will be shared with relevant education authorities. In all the platforms, the data shall be presented in a confidential codified manner.

7. PARTICIPATION AND WITHDRAWAL

You have the choice to decide whether to participate in the assessment or not. If you volunteer to participate, you may withdraw at any time you are no longer comfortable to carry on without penalties of any kind. You may refuse to attempt any questions you are not comfortable with and still remain in the study. You may be withdrawn from the assessment if you are found violating assessment ethics or engaging in any act that may undermine the study's reliability.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact me (the Investigator):
Dr. Raymond Ndubisi Anyanwu, Department of Curriculum Studies, Faculty of Education, Stellenbosch University; Tel: 081 069 9141, email: raymondanyanwu@gmail.com

Or my supervisor
Professor Peter Beets, Department of Curriculum Studies, Faculty of Education, Stellenbosch University; Tel: 021 808 2298, email: padb@sun.ac.za

Or my co-supervisor
Professor Lesley Le Grange, Department of Curriculum Studies, Faculty of Education, Stellenbosch University; Tel: 021 808 2280 email: llg@sun.ac.za

9. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms. Maléne Fouché (mfouche@sun.ac.za, 021 808 4622) at the Division for Research Development, Stellenbosch University.

SIGNATURE OF RESEARCH PARTICIPANT

The information above was described to [me/the subject/the participant] by Dr. Raymond N. Anyanwu in English and I am in command of this language. I was given the opportunity to ask questions and the questions were answered to my satisfaction. I hereby consent voluntarily to participate in this study.

.... Signature of Participant

.... Date

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to participant who signed above. He/she was encouraged and given ample time to ask me any questions. This conversation was conducted in English and no translator was used.

.... Signature of Investigator

.... Date

2

Appendix 5: A Copy of the Consent Form (in Afrikaans)

S

TOESTEMMING OM DEEL TE NEEM AAN NAVORSING

TITEL VAN STUDIE: AN ASSESSMENT OF CLIMATE CHANGE SCIENCE LITERACY AND CLIMATE CHANGE PEDAGOGY LITERACY OF GEOGRAPHY TEACHERS IN THE WESTERN CAPE PROVINCE

U word vriendelik versoek om aan 'n navorsingsprojek van **Dr. Raymond Ndubisi Anyanwu: D. Ed (UNISA), M. Ed (Port Harcourt), B.Sc. Ed (UNN), van die Departement Kurrikulumstudie, Fakulteit Opvoedkunde, Stellenbosch Universiteit**, deel te neem. Die resultate sal tot die skryf van 'n verhandeling en die publisering van akademiese navorsingsartikels bydra. U is gekies as 'n moontlike deelnemer op grond van u status as 'n geografie-onderwyser in die Wes-Kaap waar die studie gedoen word.

1. **DOEL VAN DIE STUDIE**
Die doel van die studie is om die mate waartoe geografie-onderwysers geletterd is oor klimaatsverandering-wetenskap en klimaatsverandering-pedagogie te meet.

2. **PROSEDURE**
As u instem om aan die studie deel te neem, vra ons u om:
a) die vraelys, wat tussen 15 en 30 minute sal neem, te voltooi.
b) agtergrondsinligting te verskaf oor uself en u skool, en
c) 'n stel meerkeusige vrae oor klimaatsveranderingwetenskap en -pedagogie te beantwoord.

3. **MOONTLIKE RISIKO EN ONGERIEF**
Daar is geen ooglopende risiko vir u deelname in die studie nie.

4. **MOONTLIKE VOORDELE VIR DEELNEMERS EN/OF DIE GEMEENSKAP**
U deelname in die assessering het 'n groot voordeel vir u professionele ontwikkeling. U behoort nuwe kennis oor klimaatverandering in te win en idees oor die onderrig van klimaatsverandering te stimuleer. Die uitkomste van die studie beloof om die onderwysgemeenskap se verstaan van die geletterdheid van geografie-onderwysers in die Wes-Kaap oor klimaatsverandering en die onderrig daarvan te verhoog. So kan die bevindinge in toekomstige navorsing oor geografie-onderwysers se geletterdheid van klimaatsveranderingwetenskap en -pedagogie in ander kontekste gebruik word.

5. **BETALING VIR DEELNAME**
Deelname in die assessering is beide vrywillig en gratis. Gevolglik is daar geen betaling vir u deelname, beide finansieel en in guns nie.

6. **VERTROULIKHEID**
Enige inligting wat u gee in die vraelys bly vertroulik en sal slegs met u toestemming bekendgemaak of soos deur die wet vereis word. Ten einde vertroulikheid in die studie te verseker, sal u naam of dié van u skool nooit genoem word nie (dit word nie op die vraelys vereis nie). Alle data word in wagwoord-beskermde lêers gestoor en slegs ek en my studie-leiers het daartoe toegang.

Wanneer die studie voltooi is, sal die bevindinge in plaaslike en internasionale joernale gepubliseer word en by plaaslike en internasionale kongresse insluitend by ander platforms vir intellektuele diskoers oor klimaatsverandering aangebied word. Nuwe insigte uit die studie sal met relevante onderwysowerhede gedeel word. Op al die platforms sal die data op 'n vertroulike en gekodifiseerde manier voorgestel word.

7. **DEELNAME EN ONTTREKKING**
Dit is u keuse of u in die assessering wil deelneem of nie. As u instem om deel te neem, mag u ter eniger tyd sonder enige penalisering onttrek as u nie langer gemaklik voel om aan te gaan nie. U kan weier om enige vrae te beantwoord indien u ongemaklik is en nog steeds deel bly van die studie. U kan van die assessering onttrek word indien gevind word dat u nie assesseringsetiek eerbiedig nie of so handel dat die studie se betroubaarheid in gevaar gestel word.

8. **IDENTIFISERING VAN DIE NAVORSER(S)**
Indien u enige vrae of besorgdhede het oor die navorsing, staan dit u vry om myself (die navorser) te kontak: Dr. Raymond Ndubisi Anyanwu, Departement Kurrikulumstudie, Fakulteit Opvoedkunde, Stellenbosch Universiteit; Tel: 081 069 9141, epos: raymondanyanwu@gmail.com
Of my studieleier: Professor Peter Beets, Departement Kurrikulumstudie, Fakulteit Opvoedkunde, Stellenbosch Universiteit; Tel: 021 808 2298, epos: padb@sun.ac.za
Of die mede-studieleier: Professor Lesley Le Grange, Departement Kurrikulumstudie, Fakulteit Opvoedkunde, Stellenbosch Universiteit; Tel: 021 808 2280 epos: llg@sun.ac.za

9. **REGTE VAN NAVORSINGSDEELNEMERS**
U mag u toestemming enige tyd onttrek en u deelname staak sonder enige penalisering. U gee geen wetlike eise, regte of middels op weens u deelname aan hierdie studie nie. Indien u enige vrae oor u regte as navorsingsdeelnemer het, kontak Me. Maléne Fouché (mfouche@sun.ac.za, 021 808 4622) by die Afdeling vir Navorsingsontwikkeling, Stellenbosch Universiteit.

HANDTEKENING VAN DIE DEELNEMER IN DIE NAVORSING

Die inligting hierbo was aan my die deelnemer in teks of verbaal in Afrikaans deur Dr. Raymond N. Anyanwu beskryf. Ek is in beheer van hierdie taal. Ek gee hiermee toestemming om vrywillig deel te neem aan hierdie studie.

....
Handtekening van deelnemer **Datum**

HANDTEKENING VAN DIE NAVORSER

Ek verklaar dat ek die inligting in hierdie dokument aan die deelnemer, wat hierbo geteken het, meegedeel het. Hy/sy was aangemoedig vrae te vra of te onttrek indien daar enige onsekerheid was. Hierdie kommunikasie was gedoen in Afrikaans en geen tolking was gebruik nie.

Handtekening van die navorser

11 April 201

2 | Page

Appendix 6: Pilot Questions

PS/02

LITERACY QUESTIONNAIRE

CLIMATE CHANGE SCIENCE = 13/30

AND

CLIMATE CHANGE PEDAGOGY = 10/20

Developed by
RN Anyanwu, Dept. of Curriculum Studies (Geography), Stellenbosch University

GENERAL INSTRUCTIONS

Dear colleagues,

This questionnaire, consisting of THREE main parts, aims to develop an understanding of teachers' literacy of climate change science and climate change pedagogy, respectively.

- Part 1, consisting of 9 items, deals with background details of the school and the teacher.
- Part 2, comprising 30 multiple-choice questions, focuses on climate change science.
- Part 3, consisting of 20 multiple-choice questions, focuses on climate change pedagogy.

You are kindly requested to give response to all questions in the three parts.

At the beginning of each part of this questionnaire are instructions to guide you. It is advised that you read the instructions carefully before attempting the questions.

To ensure that the findings of the study are trustworthy (reliable), you are asked to please complete this questionnaire on your own. Thus, you are expected **NOT TO CONSULT** any person(s), books, internet sources or any other sources that provide information on climate change and the methods of teaching climate change concepts in the course of attempting the questions.

Do not write your name or the name of your school on this questionnaire. The Unique Number on the cover page is generated for the purpose of data analysis only.

Be assured that the information given in this questionnaire shall be used for research purposes only and will remain confidential.

Yours sincerely

Raymond N. Anyanwu
Department of Curriculum Studies (Geography)
Stellenbosch University
Cell: 081 069 9141
Email: raymondanyanwu@gmail.com

PART 1: BACKGROUND DETAILS OF SCHOOLS AND GEOGRAPHY TEACHERS

INSTRUCTIONS

This part consists of 9 items. Insert √ (a tick) in the rectangle bearing the correct information.

SECTION A: SCHOOL DETAILS				
1. District where school is situated	Metro Central	Metro East	Metro North	Metro South
	West Coast	Overberg	Eden & Central Karoo	Cape Winelands
2. School location type	Rural	Semi-urban ✓	Urban	
3. School type	Boys only	Girls only	Mixed (Co-educational) ✓	
4. Approximate number of learners	Fewer than 1000 ✓	Over 1000		
5. Number of teachers	Fewer than 30 ✓	Over 30		
6. Number of FET Geography teachers	1	2 ✓	More than 2	

SECTION B: TEACHER DETAILS				
1. Gender	Male	Female ✓		
2. Age range (in years)	Less than 25 ✓	25-40	Over 40	
3. Highest qualifications	Ordinary Diploma	Bachelor ✓	Honours	
	Postgraduate Diploma	Master	Doctorate	
4. Subject specialisation	Geography only	Geography/Education ✓	Any other (specify):	
5. Main teaching subject(s)	Geography only	Geography and other subjects (specify subjects): Maths Lit		
6. No. of years in teaching	Less than 5 ✓	5 to 10 years	Over ten years	
7. The Grade(s) you mostly teach	10 ✓	11	12	
8. Number of learners that you teach Geography	Fewer than 50 ✓	Over 50		
9a. Have you taught lessons on climate change in last year?	Yes	No ✓		
b. If your answer to 9a is 'Yes', answer sub items i and ii. — i) Where do you mainly get the information on climate change content and concepts	Television	Radio	Internet	Newspaper
	School textbooks	Workshops/seminars	Peers/Subject Advisor	
ii) Where do you mainly get information on methods of teaching climate change	Television	Radio	Internet	Newspaper
	School textbooks	Workshop/seminar	Peers/Subject Advisor	

PART 2: CLIMATE CHANGE SCIENCE

INSTRUCTIONS

This part consists of 30 multiple-choice questions. Each question has four options lettered A to D and one of the options is the most correct answer. Write the letter bearing the most correct answer in the square on the extreme right to the options provided. For example:

QUESTION

The instrument for measuring atmospheric temperature is

A. Thermometer
B. Spectrometer
C. Barometer
D. Hygrometer

$\boxed{A}$

QUESTION 1

The main difference between weather and climate is a matter of

A. Temperature
B. Rainfall
C. Place
D. Time

$\boxed{D}$

QUESTION 2

It is the most abundant greenhouse gas and also the most important contributor to natural greenhouse effect.

A. Methane
B. Carbon dioxide
C. Water vapour
D. Nitrous oxide

$\boxed{B}$

QUESTION 3

Which of these best describes the greenhouse effect?

A. Warming of the Earth's lower atmosphere due to indiscriminate destruction of natural vegetation.
B. Trapping heat in Earth's lower atmosphere due to presence of trace gases and water vapour
C. Obstruction of atmospheric visibility due to haze, mist, blowing sand, smoke, spay and volcanic ash
D. Increased concentration of the ozone layer due to high the concentration of chlorofluorocarbons

$\boxed{D}$

QUESTION 4

One of these occurs when warmer ocean currents from the tropics move towards the polar latitudes.

A. Surface temperature in the polar latitudes increases
B. Surface temperature in the polar latitudes drops
C. Surface temperature in the tropics increases
D. Surface temperature in the tropics decreases

A

QUESTION 5

The term *global warming* refers to

A. a high concentration of carbon dioxide in the lower atmosphere
B. rapid changes in dynamics and processes of the climate system
C. changes in global climate and local weather patterns
D. increase in mean temperature of the Earth's atmosphere

C

QUESTION 6

All of these are examples of natural causes of climate change, except

A. The very slow drift of continents over millions of years
B. The changing intensity of radiation emitted by the sun
C. Volcanic eruptions, which inject ash and sulphur compounds into the atmosphere
D. Release of industrial greenhouse gases into the lower atmosphere

A

QUESTION 7

Which of the groups is not preserved physical characteristics of the past that can be used by scientists to reconstruct past climates?

A. Pollens, corals
B. Ice cores, ocean and lake sediments
C. Computer models, experiments
D. Tree rings, records of harvest production

A

QUESTION 8

Processes leading to climate change take a long time. With the current concentration of CO_2 in the Earth's atmosphere it is most likely that global warming will

A. stop in less than a decade
B. continue for a very long time
C. less in the developing countries
D. less in the highly industrialised countries

B

QUESTION 9

Climate change science is characterised by

A. precision
B. uncertainty
C. consensus
D. positive feedbacks

C

QUESTION 10

The table below shows world leading CO_2 emitters mainly emissions from fossil-fuel burning, cement manufacturing and gas flaring in 2011.

Countries	Annual CO_2 emission (in tonnes)	CO_2 Emission Per Capita
1	9, 700, 000	7.2
2	5, 420, 000	17.2
3	1, 970, 000	1.6
4	1, 830, 000	12.6
5	1, 240, 000	9.8

Which country in the world tops the list (number one on the table) in terms of annual emissions?

A. Russia
B. South Africa
C. China
D. United States

L

QUESTION 11

All the options below can be evidence of global warming, except

A. global population rise
B. global temperature rise
C. sea level rise
D. shrinking ice sheets

A

QUESTION 12

A reduction in the length of the growing seasons of plants due to global warming may cause all except

A. decrease in human death rate
B. unemployment
C. poverty
D. food insecurity

A

QUESTION 13

One of these may not occur as a result of the effect of climate change on reservoirs.

A. Low hydroelectric power generation
B. A reduction in the amount of available water
C. Low food production
D. Decline in marine biota population

C

QUESTION 14

Atmospheric supply of moisture in an area minus atmospheric demand for moisture in that area on could provide clues about

A. Heat wave
B. Diseases outbreak
C. Drought
D. Flood

A

QUESTION 15

The causative agent of one these diseases may not be linked to global warming.

A. HIV/AIDS
B. Diarrhoea
C. Dengue fever
D. Malaria

A

QUESTION 16

Most sub-Saharan African countries are highly vulnerable to climate change mainly because of their

A. low CO_2 emissions per capita
B. low adaptive capacity
C. high CO_2 emission per capita
D. high adaptive capacity

B

QUESTION 17

A reduction in economic growth due to global warming may result in all of these in developing countries, except

A. in-migration
B. reduced income opportunities
C. decrease in outbreak of diseases
D. poor service delivery

A

QUESTION 18

Excessive heat occurring due to enhanced greenhouse warming is likely to have more negative impact on populations in the northern hemisphere than population in the southern hemisphere because

A. northern hemisphere lacks the technology to address global warming
B. northern hemisphere is more populated than southern hemisphere
C. southern hemisphere is more populated than northern hemisphere
D. southern hemisphere is less vulnerable to global warming impacts

D

QUESTION 19

Which of these does not explain why climate change may not affect food security in oil-rich countries of the Middle East?

A. More than half of the region's population are employed in oil companies
B. Their domestic agricultural production is small
C. They have a lot of foreign currency reserve to import food
D. They have well-developed food manufacturing industries

C

QUESTION 20

In every country the poor are the most affected by climate change. This is because

A. governments do not provide quality services to rural communities
B. global warming occurs more in rural areas than in urban areas
C. population control policies does not favour poor people
D. the poor have limited access to resources

D

QUESTION 21

Which of these is not associated with analysis of a local district's vulnerability to climate change?

A. examine the district's exposure to climate shocks and stresses
B. model future climate impacts on the district
C. analyse the adaptive capacity of individuals and households in the district
D. estimate per capita carbon emission in the district

C

QUESTION 22

One of these is not a community-based adaptation to climate change.

A. initiate projects aimed at poverty eradication
B. introduce national policies to achieve carbon emissions reduction targets
C. establish disaster-risk reduction centres in rural areas
D. encourage local people's participation in natural resource conservation

A

QUESTION 23

All the options below are the various ways in which animals can adjust to change and variability of global climate patterns, except

A. maintain a constant breeding period
B. migrate to a new location
C. develop climate change tolerance
D. adapt to changing food sources

A

QUESTION 24

In climate change literature the term stabilisation refers to

A. trading of carbon between developed and developing countries
B. enhancing people's ability to cope with climate catastrophes
C. reduction of atmospheric carbon concentration to a less harmful level
D. promoting green technology in developing countries

C

QUESTION 25

Which of these may not facilitate the implementation of new policies on climate change?

A. ensuring that all citizens make an input in formulating policies on climate change
B. enhancing the capacity of the media to educate communities about climate change
C. involving marginalised communities in climate change discourse
D. educating children and young people in schools about climate change

A

QUESTION 26

An investment by a company in the European Union intended to enable a district heating system in South Africa to switch from coal to natural gas and to improve the efficiency of the system refers to

A. Joint Implementation (JI)
B. Clean Development Mechanism (CDM)
C. International Emissions Trading (IET)
D. Carbon Capture and Storage (CCS)

B

QUESTION 27

The term 'carbon sequestration' means

A. interruptions of the carbon cycle by human being
B. the removal of CO_2 from the atmosphere and depositing it in reservoir
C. flow of CO_2 through the oceans, terrestrial biosphere and lithosphere
D. production of large quantities of CO_2 from industrial processes

A

QUESTION 28

Which of these options would be most suitable for a developing country like South Africa, if global warming continues for many years?

A. Intensify effort to reduce greenhouse gas (GHG) concentrations
B. Business as usual until climate change reversed on its own
C. Initiate programmes that will curb harm from current climate changes
D. Obtain adequate information on present and future climate changes

A

QUESTION 29

Which of the measures may not enhance the capacity of the poor to adapt to climate change?

A. eradicating extreme poverty and hunger
B. achieving universal primary education
C. achieving a reduction in crime rate
D. developing a global partnership for development

C ✓

QUESTION 30

One of these is associated with South Africa.

A. COP16/CMP6
B. COP17/CMP7
C. COP18/CMP8
D. COP19/CMP9

C

13/30

QUESTION 14

One of the teachers in your school often complains that some students encounter difficulty in formulating their own ideas when learning new concepts relating to climate change. Which of these strategies should this teacher emphasise in subsequent lessons?

A. Making judicious use of learning time
B. Completing tasks independently
C. Predicting the trends of future events.
D. Thinking before providing answers to questions

D

QUESTION 15

A teacher begins a lesson on the causes of climate change by first providing an outline of the key concepts that will be covered in the course of the lesson before going ahead to progressively differentiate them. This teaching strategy is referred to as.

A. lesson transition
B. advance organiser
C. content development
D. lesson pacing

C

QUESTION 16

A teacher is working tirelessly to expose his or her students to tasks and conditions that are dissimilar to those that they will encounter later in their localities. This teacher's effort is likely to promote

A. concept learning
B. cooperative learning
C. inquiry learning
D. transfer of learning

C

QUESTION 17

A teacher asks his or her students to initiate actions that will help to reduce the impacts of climate change in their localities. Which of these contains the geographical inquiry steps that the learners could follow to find solutions?

A. Compile relevant information about a problem; understand the nature of the problem; evaluate the solution; formulate and carry out a solution; identify the problem
B. Identify a problem; formulate and carry out a solution; understand the nature of the problem; compile relevant information about the problem; evaluate the solution
C. Compile relevant information about the problem; evaluate the solution' understand the nature of the problem; identify a problem; formulate and carry out a solution
D. Identify a problem; understand the nature of the problem; compile relevant information about the problem; formulate and carry out a solution; evaluate the solution

D

QUESTION 18

A teacher can take the opportunity of a lesson on climate change to nurture learner self-regulation. Which of these may not help in achieving this objective?

A. Ensuring that learners copy notes and revise them prior to assessment
B. Presenting learners with case-based tasks that require application of knowledge in wider contexts
C. Integrating real-life examples with information gathered from textbooks and the internet
D. Guiding learners on how to separate relevant from irrelevant information when reading texts

$\boxed{A}$

QUESTION 19

One of these instruction phases is most appropriate to overcome students' misconceptions of global warming.

A. Investigate → Transfer → Hypothesize → Review
B. Review → Hypothesize → Transfer → Investigate
C. Hypothesize → Investigate → Review → Transfer
D. Transfer → Review → Investigate → Hypothesize

$\boxed{C}$

QUESTION 20

Some students in a class performed poorly in previous assessments on the causes of climate change due to low achievement motivation. Which of these assessment forms offers the greatest opportunity for learners to improve on their previous performance?

A. Diagnostic assessment
B. Summative assessment
C. Baseline assessment
D. Formative assessment

$\boxed{D}$

==================================END OF QUES==

10/20

COMMENTS

I thank you for your time to complete this questionnaire. Your comments on the questionnaire will help me to make necessary changes that will lead to its improvement for future use.

a. Instructions:

- [ ] Instructions are confusing
- [x] Instructions are clear

b. Length of questionnaire (number of questions):

- [ ] Too long
- [ ] Too short
- [x] Suitable

c. Difficulty level of the questions:

- [ ] Too easy
- [ ] Too difficult
- [x] Suitable

d. Wording of questions:

- [x] Easy to understand
- [ ] Difficult to understand

e. Any other comments:

....
....
....
....
....
....

Appendix 7: A Copy of the CCSL and CCPL Questionnaire (in English)

LITERACY QUESTIONNAIRE

CLIMATE CHANGE SCIENCE

AND

CLIMATE CHANGE PEDAGOGY

Developed by RN Anyanwu, Dept. of Curriculum Studies (Geography), Stellenbosch University

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GENERAL INSTRUCTIONS

Dear Colleagues

This questionnaire aims to develop an understanding of teachers' literacy of climate change science and climate change pedagogy, respectively.

The paper is divided into sections:

- Section 1 deals with background of the school and the teacher
- Section 2 focuses on understanding of climate change
- Section 3 focuses on teaching of climate change

You are kindly requested to answer all questions in the three sections.

Read the instructions carefully before attempting the questions.

To ensure that the study's findings are trustworthy (reliable), you are asked to please complete this questionnaire on your own. Thus, you are expected **NOT TO CONSULT** any person(s), books, internet sources or any other sources that provide information on climate change and the methods of teaching climate change concepts in the course of attempting the questions.

Do not write your name or the name of your school on this questionnaire.

The Unique Number on the cover page is generated for the purpose of data analysis only.

Be assured that the information given in this questionnaire shall be used for research purposes only and will remain confidential.

With regards

Raymond N. Anyanwu
Department of Curriculum Studies (Geography)
Stellenbosch University
Cell: 081 069 9141
Email: raymondanyanwu@gmail.com

SECTION 1: BACKGROUND DETAILS OF YOUR SCHOOL AND YOU AS A GEOGRAPHY TEACHER

INSTRUCTIONS

Insert √ (a tick) close to information that applies to you. Choose one option in each case.

A: YOUR SCHOOL'S DETAILS

1. District where school is situated	Metro Central	Metro East	Metro North	Metro South
	West Coast	Overberg	Eden & Central Karoo	Cape Winelands
2. School location type	Rural	Semi-urban	Urban	
3. School type	Boys only	Girls only	Mixed (Co-educational)	
4. Approximate number of learners	Fewer than 1000	Over 1000		
5. Number of teachers	Fewer than 30	Over 30		
6. Number of FET Geography teachers	1	2	More than 2	

B: YOUR DETAILS

1. Gender		Male	Female		
2. Age range (in years)		Less than 25	25-40	Over 40	
3. Highest qualification		Ordinary Diploma	Bachelor Degree	Honours Degree	
		Postgraduate Diploma	Masters Degree	Doctorate Degree	
4. Subject specialisation		Geography only	Geography in Education	Others (specify):	
5. No. of years in teaching		Less than 5 years	6-10 years	More than 10 years	
6. The Grade you mostly teach (*Choose one only*)		10	11	12	
7. Number of learners that you teach Geography		Fewer than 50	More than 50		
8a. Have you taught lessons on climate change in the last year?		Yes	No		
b. If your answer to 8a is 'Yes', answer sub items i and ii (*Choose one in each case*).	i) Where do you mainly get information on climate change content and concepts?	Television	Radio	Internet	Newspaper
		School textbooks	Workshops/seminars	Peers/Subject Advisor	
	ii) Where do you mainly get information on methods of teaching climate change?	Television	Radio	Internet	Newspaper
		School textbooks	Workshop/seminar	Peers/Subject Advisor	

SECTION 2: CLIMATE CHANGE SCIENCE

INSTRUCTIONS

Each question in this section has four options lettered A to D and one of the options is the most correct answer. Insert X in the box in front of the most correct answer.

For example:

The instrument for measuring atmospheric temperature is

- ☒ **A. Thermometer**
- ☐ **B. Spectrometer**
- ☐ **C. Barometer**
- ☐ **D. Hygrometer**

1. One of these options is the most abundant greenhouse gas and also the most important contributor to natural greenhouse effect.

- ☐ A. Methane
- ☐ B. Carbon dioxide
- ☐ C. Water vapour
- ☐ D. Nitrous oxide

2. The term *global warming* refers to

- ☐ A. a high concentration of carbon dioxide in the lower atmosphere
- ☐ B. rapid changes in dynamics and processes of the climate system
- ☐ C. changes in global climate and local weather patterns
- ☐ D. increase in the average temperature of the Earth's atmosphere

3. Which of the options below is an anthropogenic cause of climate change?

- ☐ A. Slow drifting of continents over millions of years
- ☐ B. Inconstant intensity of radiation emitted by the sun
- ☐ C. Volcanic eruptions that inject ash and sulphur compounds into the atmosphere
- ☐ D. Release of industrial greenhouse gases into the lower atmosphere

4. Which of these statements is correct, given the amount of CO_2 currently in the Earth's atmosphere?

- ☐ A. There will be a reduction of global warming in the next few decades
- ☐ B. Global warming will continue for many centuries
- ☐ C. Developing countries will experience less warming
- ☐ D. Highly industrialised countries will experience less warming

5. Climate change science is characterised by

- ☐ A. precision
- ☐ B. uncertainty
- ☐ C. consensus
- ☐ D. feedback

6. One of the options below is an evidence of global warming.

- ☐ A. Decrease in ice sheets
- ☐ B. Decrease in global temperature
- ☐ C. Decrease in sea level
- ☐ D. Decrease in ocean salinity

7. Atmospheric supply of moisture in an area minus atmospheric demand for moisture in that area can give an indication of

- ☐ A. heat waves
- ☐ B. disease outbreaks
- ☐ C. droughts
- ☐ D. floods

8. Most sub-Saharan African countries are vulnerable to climate change because they have

- ☐ A. low CO_2 emissions per capita
- ☐ B. poor capacity to adapt to climate changes
- ☐ C. high CO_2 emissions per capita
- ☐ D. good capacity to adapt to climate changes

9. Which of these options is **not** caused by climate change in less developed countries?

- ☐ A. Low out-migration
- ☐ B. Low income opportunities
- ☐ C. Low outbreak of diseases
- ☐ D. Poor service delivery

10. Too much heat due to an increase in greenhouse warming may have more negative effect on people in the northern hemisphere than people in the southern hemisphere because

- ☐ A. the northern hemisphere lacks the technology to deal with global warming
- ☐ B. the northern hemisphere is more populated than the southern hemisphere
- ☐ C. the southern hemisphere is more populated than the northern hemisphere
- ☐ D. the southern hemisphere is less vulnerable to global warming impacts

11. The term 'carbon sequestration' means

- ☐ **A**. interruptions of the carbon cycle by human beings
- ☐ **B**. the removal of CO_2 from the atmosphere and depositing it in reservoirs
- ☐ **C**. flow of CO_2 through the oceans, biosphere and lithosphere
- ☐ **D**. production of large quantities of CO_2 from industrial processes

12. One of these is **not** a community-based adaptation to climate change.

- ☐ **A**. Implementing projects aimed at poverty eradication
- ☐ **B**. Implementing guidelines to achieve carbon emission reduction targets
- ☐ **C**. Establishing disaster-risk reduction centres in rural areas
- ☐ **D**. Encouraging local people's participation in natural resource conservation

13. Which of these may hinder the implementation of new policies on climate change?

- ☐ **A**. Ensuring that climate experts alone formulate climate change policies
- ☐ **B**. Enhancing the capacity of the media to educate communities about climate change
- ☐ **C**. Involving rural communities in climate change discourse
- ☐ **D**. Educating children and youth about climate change

14. Which of the options below is the best for developing countries, if climate change does not stop soon?

- ☐ **A**. Reduce the amount of greenhouse gas in the atmosphere
- ☐ **B**. Carry on with business as usual until climate change stops
- ☐ **C**. Implement programmes that will reduce the harmful effect of climate change
- ☐ **D**. Search for more scientific information on present and future climate changes

15. One of these initiatives is associated with South Africa.

- ☐ **A**. COP16/CMP6
- ☐ **B**. COP17/CMP7
- ☐ **C**. COP18/CMP8
- ☐ **D**. COP19/CMP9

SECTION 3: CLIMATE CHANGE PEDAGOGY (TEACHING)

INSTRUCTIONS

Each question in this section has four options lettered A to D and one of the options is the most correct answer. Insert X in the box in front of the most correct answer, as in Section 2.

1. Children are the most affected by climate change because

- ☐ **A**. the population of children and young people is large
- ☐ **B**. children have limited access to resources
- ☐ **C**. most parents do not take proper action to protect their children
- ☐ **D**. many children in schools lack discipline

2. Which of the options below **is not** an objective of climate change education?

- ☐ **A**. Helping learners to understand the causes and effects of climate change.
- ☐ **B**. Empowering learners to take actions that will help them to adapt to climate change.
- ☐ **C**. Enabling learners to debate issues relating to climate change.
- ☐ **D**. Empowering learners to decide on new policies on climate change

3. Teaching learners that social equality in society can be achieved when natural resources are managed effectively will help them understand that

- ☐ **A**. society, natural resources and development are connected
- ☐ **B**. natural resources cannot be exhausted
- ☐ **C**. society does not require natural resources to achieve social equality
- ☐ **D**. development, society and natural resources are unrelated

4. One of the options below **is not** a mathematical skill needed for conducting climate change vulnerability analysis.

- ☐ **A**. Inferential reasoning
- ☐ **B**. Measurement
- ☐ **C**. Identifying issues
- ☐ **D**. Modelling

5. Assessing a variety of climate change adaptation options, choosing the best from among the options, and being aware of consequences of the choices that one makes are examples of

- ☐ **A**. information processing
- ☐ **B**. dialogic negotiation
- ☐ **C**. knowledge construction
- ☐ **D**. decision making

6. A learner read from a textbook that the global climate pattern is changing and humans are the main cause. Yet, this learner still doubts that there is enough proof in his or her location that requires taking immediate action. The situation that this learner finds him or herself is called

- ☐ **A.** cognitive apprenticeship
- ☐ **B.** cognitive autonomy
- ☐ **C.** cognitive load
- ☐ **D.** cognitive conflict

7. One of the teachers in your school often complains that some learners have difficulty in constructing their own ideas when learning new concepts relating to climate change. Which of these strategies should this teacher emphasise in future lessons?

- ☐ **A.** Making judicious use of learning time
- ☐ **B.** Completing tasks independently
- ☐ **C.** Predicting the trends of future events
- ☐ **D.** Thinking before providing answers to questions

8. A teacher often gives his or her learners tasks and conditions similar to those that they will meet later in their home environment. This teacher's effort is likely to promote

- ☐ **A.** concept learning
- ☐ **B.** cooperative learning
- ☐ **C.** inquiry learning
- ☐ **D.** transfer of learning

9. Which of the sequences listed below can a teacher apply to change the faulty concepts learners hold about global warming?

- ☐ **A.** Investigate → Transfer → Hypothesize → Review
- ☐ **B.** Review → Hypothesize → Transfer → Investigate
- ☐ **C.** Hypothesize → Investigate → Review → Transfer
- ☐ **D.** Transfer → Review → Investigate → Hypothesize

10. Some learners in a class performed poorly in previous assessments on the causes and effects of climate change. Which of these assessment forms provides the greatest opportunity for learners to close the gap in their understanding?

- ☐ **A.** Diagnostic assessment
- ☐ **B.** Summative assessment
- ☐ **C.** Baseline assessment
- ☐ **D.** Formative assessment

==END==

Thanks for your participation in this study

Appendix 8: A Copy of the CCSL and CCPL Questionnaire (in Afrikaans)

GELETTERDHEIDSVRAELYS

KLIMAATSVERANDERING-WETENSKAP

EN

KLIMAATSVERANDERING-PEDAGOGIE

Ontwikkel deur RN Anyanwu, Dept. van Kurrikulumstudie (Geografie), Stellenbosch Universiteit

Maart 2014

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ALGEMENE INSTRUKSIES

Geagte Kollegas

Hierdie vraelys het dit ten doel om 'n begrip van onderskeidelik onderwysers se geletterdheid oor die wetenskap van klimaatsverandering en klimaatsverandering-pedagogie te ontwikkel.

Die vraelys is in afdelings verdeel:

- Afdeling 1 handel oor die agtergrond van die skool en die onderwyser
- Afdeling 2 fokus op die verstaan van klimaatsverandering
- Afdeling 3 fokus op die onderrig van klimaatsverandering

U word vriendelik versoek om alle vrae in die drie afdelings te beantwoord.

Lees asseblief die instruksies versigtig deur voordat u begin om die vrae te beantwoord.

Ten einde te verseker dat die bevindinge van die studie (ondersoek) geloofwaardig (betroubaar) is, word u versoek om die vraelys op u eie te beantwoord. Gevolglik word van u verwag om **GEEN** persone, boeke, internetbronne of enige ander bronne wat inligting oor klimaatsverandering of metodes om klimaatsverandering-konsepte te onderrig, tydens die beantwoording van die vrae, **TE RAADPLEEG NIE.**

Moet asseblief nie u naam of die van die skool op die vraelys skryf nie.

Die Unieke Nommer op die voorblad is alleenlik vir die doeleindes van die data-analise gegenereer.

Wees verseker dat die inligting wat u in hierdie vraelys voorsien slegs vir navorsingsdoeleindes gebruik gaan word en dat dit vertroulik sal bly.

Met dank en groete

Raymond N. Anyanwu
Departement van Kurrikulumstudie (Geografie)
Stellenbosch Universiteit
Selfoonnommer: 081 069 9141
Epos: raymondanyanwu@gmail.com

AFDELING 1: AGTERGRONDBESONDERHEDE VAN U SKOOL EN VAN U AS GEOGRAFIE-ONDERWYSER

INSTRUKSIES

Maak 'n √ ('n hakie) by die inligting wat op u van toepassing is. Kies een opsie in elke geval.

A: U SKOOL SE BESONDERHEDE

1. Distrik waar skool geleë is	Metro Sentraal	Metro Oos	Metro Noord	Metro Suid
	Weskus	Overberg	Eden & Sentrale Karoo	Kaapse Wynlande
2. Skool se ligging	Landelik	Semi-stedelik	Stedelik	
3. Soort skool	Slegs seuns	Slegs meisies	Gemeng (Ko-opvoedkundig)	
4. Aantal leerders by benadering	Minder as 1000	Meer as 1000		
5. Aantal onderwysers	Minder as 30	Meer as 30		
6. Aantal VOO Geografie-onderwysers	1	2	Meer as 2	

B: U BESONDERHEDE

1. Geslag		Manlik	Vroulik		
2. Ouderdom (in jare)		Minder as 25	25-40	Meer as 40	
3. Hoogste kwalifikasie		Gewone Diploma	Baccalareusgraad	Honneursgraad	
		Nagraadse Diploma	Meestersgraad	Doktorsgraad	
4. Vakspesialisering		Slegs Geografie	Geografie in die Onderwys	Ander (spesifiseer):	
5. Aantal jare in onderwys		Minder as 5 jare	6-10 jare	Meer as 10 jare	
6. Die Graad waarin u die meeste onderrig *(Kies slegs een)*		10	11	12	
7. Aantal leerders vir wie u Geografie onderrig		Minder as 50	Meer as 50		
8a. Het u lesse oor klimaatsverandering in die laaste jaar onderrig?		Ja	Nee		
b. As u antwoord by 8a 'JA' is, beantwoord asb. items i) en ii). *(Kies een in elke geval)*	i) Waar kry u meestal inligting oor klimaats-verandering-inhoud en konsepte?	Televisie	Radio	Internet	Nuusblaaie
		Skoolhandboeke	Werkswinkels/ Seminare	Portuurgroep/Vakadviseurs	
	ii) Waar kry u veral inligting oor onderrigmetodes in die onderrig van klimaatsverandering?	Televisie	Radio	Internet	Nuusblaaie
		Skoolhandboeke	Werkswinkels/ Seminare	Portuurgroep/ Vakadviseurs	

AFDELING 2: KLIMAATSVERANDERING-WETENSKAP

INSTRUKSIES

Elke vraag in hierdie afdeling het vier opsies genommer A tot D en een van die opsies is die mees korrekte antwoord. Maak 'n kruisie X in die blokkie voor die mees korrekte antwoord.

By voorbeeld:

Die instrument waarmee atmosferiese temperatuur gemeet word is 'n

- ☐ **A. Termometer**
- ☐ **B. Spektrometer**
- ☐ **C. Barometer**
- ☐ **D. Higrometer**

1. Een van die opsies is die volopste kweekhuisgas en ook die belangrikste bydraer tot natuurlike kweekhuiseffek.

- ☐ **A.** Metaan
- ☐ **B.** Koolsuurgas
- ☐ **C.** Waterdamp
- ☐ **D.** Distikstofmonoksied

2. Die term *globale verwarming* verwys na

- ☐ **A.** 'n hoë konsentrasie koolsuurgas in die laer atmosfeer
- ☐ **B.** vinnige veranderinge in die dinamiek en prosesse van die klimaatstelsel
- ☐ **C.** veranderinge in globale klimaat- en plaaslike weerpatrone
- ☐ **D.** 'n toename in die gemiddelde temperatuur van die Aarde se atmosfeer

3. Watter van die onderstaande opsies is 'n menslike oorsaak van klimaatsverandering?

- ☐ **A.** Stadige drywing van kontinente oor miljoene jare
- ☐ **B.** Ongelyke intensiteit van bestraling vanaf die son
- ☐ **C.** Vulkaniese uitbarstings wat as en swawelverbindings in die atmosfeer spuit
- ☐ **D.** Vrystelling van industriële kweekhuisgasse in die laer atmosfeer

4. Gegewe die hoeveelheid CO_2 tans in die atmosfeer, watter van hierdie stellings is korrek?

- ☐ **A.** Daar sal 'n afname in globale verwarming oor die volgende paar dekades wees
- ☐ **B.** Globale verwarming sal vir baie eeue voortduur
- ☐ **C.** Ontwikkelende lande sal minder verwarming ervaar
- ☐ **D.** Hoogsgeïndustrialiseerde lande sal minder verwarming ervaar

5. Klimaatsverandering-wetenskap word gekenmerk deur

- ☐ A. akkuraatheid
- ☐ B. onsekerheid
- ☐ C. konsensus
- ☐ D. terugvoer

6. Een van die onderstaande opsies is 'n bewys van globale verwarming.

- ☐ A. Afname in ysdekke
- ☐ B. Afname in globale temperatuur
- ☐ C. Afname in seevlak
- ☐ D. Afname in die soutgehalte van oseane

7. Atmosferiese voorsiening van vogtigheid in 'n gebied, minus die atmosferiese aanvraag na vogtigheid in daardie gebied, kan 'n aanduiding gee van

- ☐ A. hittegolwe
- ☐ B. uitbreek van siektes
- ☐ C. droogtes
- ☐ D. vloede

8. Die meeste sub-Sahara Afrika-lande is kwesbaar vir klimaatsverandering omdat hulle 'n

- ☐ A. lae CO_2 vrylating per capita het
- ☐ B. lae kapasiteit het om by klimaatsveranderinge aan te pas
- ☐ C. hoë CO_2 vrystelling per capita het
- ☐ D. hoë kapasiteit het om by klimaatsveranderinge aan te pas

9. Watter van hierdie opsies word **nie** deur klimaatsverandering in minder ontwikkelde lande veroorsaak nie?

- ☐ A. Lae uit-migrasie
- ☐ B. Lae inkomste-geleenthede
- ☐ C. Lae uitbreek van siektes
- ☐ D. Swak dienslewering

10. Te veel hitte as gevolg van 'n toename in kweekhuisverwarming mag 'n groter negatiewe uitwerking op mense in die noordelike halfrond as mense in die suidelike halfrond hê, omdat

- ☐ A. die noordelike halfrond nie die tegnologie het om globale verwarming te hanteer nie
- ☐ B. die noordelike halfrond digter bevolk is as die suidelike halfrond
- ☐ C. die suidelike halfrond digter bevolk is as die noordelike halfrond
- ☐ D. die suidelike halfrond minder kwesbaar vir die impak van globale verwarming is

11. Die term 'koolstofsekwestrasie' beteken

- ☐ A. onderbrekings in die koolstofsiklus deur menslike wesens
- ☐ B. die verwydering van CO_2 uit die atmosfeer en die deponering daarvan in reservoirs
- ☐ C. die vloei van CO_2 deur die oseane, biosfeer en litosfeer
- ☐ D. produksie van groot hoeveelhede CO_2 in industriële prosesse

12. Een van hierdie is **nie** 'n gemeenskapsgebaseerde aanpassing by klimaatsverandering nie.

- ☐ A. Implementering van projekte gemik op armoedeverligting
- ☐ B. Implementering van riglyne om mikpunte vir die vermindering van koolstofvrystelling te bereik
- ☐ C. Vestiging van ramp-risikoverminderingsentra in landelike gebiede
- ☐ D. Aanmoediging van plaaslike mense se deelname aan natuurlike hulpbronbewaring

13. Watter van hierdie mag die implementering van nuwe beleid oor klimaatsverandering belemmer?

- ☐ A. Versekering dat klimaatkundiges alleen beleid oor klimaatsverandering formuleer
- ☐ B. Verhoogde kapasiteit van die media om gemeenskappe oor klimaatsverandering op te voed
- ☐ C. Betrekking van landelike gemeenskappe by die gesprek oor klimaatsverandering
- ☐ D. Opvoeding van kinders en die jeug oor klimaatsverandering

14. Watter van die onderstaande opsies is die beste vir ontwikkelende lande indien klimaatsverandering nie vinnig stop nie?

- ☐ A. Verminder die hoeveelheid kweekhuisgas in die atmosfeer
- ☐ B. Gaan voort soos gewoonlik totdat klimaatsverandering stop
- ☐ C. Implementeer programme wat die skadelike gevolge van klimaatsverandering sal verminder
- ☐ D. Soek vir meer wetenskaplike inligting oor huidige en toekomstige klimaatsveranderinge

15. Een van hierdie inisiatiewe word met Suid-Afrika geassosieer.

- ☐ A. COP16/CMP6
- ☐ B. COP17/CMP7
- ☐ C. COP18/CMP8
- ☐ D. COP19/CMP9

AFDELING 3: KLIMAATSVERANDERING-PEDAGOGIE (ONDERRIG)

INSTRUKSIES

Elke vraag in hierdie afdeling het vier opsies genommer A tot D en een van die opsies is die mees korrekte antwoord. Maak 'n kruisie X in die blokkie voor die mees korrekte antwoord, soos in Afdeling 2.

1. Kinders word die meeste deur klimaatsverandering geaffekteer omdat

- ☐ **A.** die bevolking van kinders en jong mense groot is
- ☐ **B.** kinders beperkte toegang tot hulpbronne het
- ☐ **C.** die meeste ouers nie gepaste stappe neem om hul kinders te beskerm nie
- ☐ **D.** die meeste kinders in skole nie gedissiplineerd is nie

2. Watter van die onderstaande opsies **is nie** 'n doelstelling van klimaatsverandering-opvoeding nie?

- ☐ **A.** Leerders te help om die oorsake en gevolge van klimaatsverandering te verstaan.
- ☐ **B.** Leerders te bemagtig om stappe te neem wat hulle sal help om by klimaatsverandering aan te pas.
- ☐ **C.** Leerders in staat te stel om oor kwessies rakende klimaatsverandering te debatteer.
- ☐ **D.** Leerders te bemagtig tot besluitneming oor nuwe beleid met betrekking tot klimaatsverandering

3. Deur leerders te onderrig dat sosiale gelykheid in die gemeenskap bereik kan word deur die effektiewe bestuur van natuurlike hulpbronne, help dit hulle om te verstaan dat

- ☐ **A.** die gemeenskap, natuurlike hulpbronne en ontwikkeling verband hou met mekaar
- ☐ **B.** natuurlike hulpbronne opgebruik kan word
- ☐ **C.** die gemeenskap nie natuurlike hulpbronne benodig om sosiale gelykheid te bereik nie
- ☐ **D.** ontwikkeling, gemeenskap en natuurlike hulpbronne nie verband hou met mekaar nie

4. Een van die onderstaande opsies **is nie** 'n wiskundige vaardigheid wat benodig word tydens die uitvoering van 'n klimaatsverandering-kwesbaarheidsanalise nie.

- ☐ **A.** Inferensiële redenasie
- ☐ **B.** Meting
- ☐ **C.** Identifisering van vraagstukke
- ☐ **D.** Modellering

5. By die assessering van 'n verskeidenheid klimaatsveranderingsaanpassingsopsies, die kies van die beste opsie, en die bewuswees van die gevolge van keuses, is voorbeelde van

- ☐ **A.** inligtingprosessering
- ☐ **B.** onderhandeling tydens gespreksvoering
- ☐ **C.** kenniskonstruksie
- ☐ **D.** besluitneming

6. 'n Leerder lees in 'n handboek dat die globale klimaatspatroon verander en dat mense die hoof oorsaak is. Tog twyfel die leerder steeds of daar genoeg bewyse in sy of haar plaaslike omgewing is wat vereis dat onmiddellike aksie geneem moet word. Die situasie waarin die leerder hom of haar bevind, word genoem

- ☐ A. kognitiewe vakleerlingskap
- ☐ B. kognitiewe outonomie
- ☐ C. kognitiewe lading
- ☐ D. kognitiewe konflik

7. Een van die onderwysers in jou skool kla gereeld dat sommige leerders probleme het om hul eie idees te vorm wanneer hulle nuwe konsepte aanleer wat met klimaatsverandering verband hou. Watter van hierdie strategieë moet die onderwyser beklemtoon in toekomstige lesse?

- ☐ A. Maak oordeelkundig gebruik van leertyd
- ☐ B. Voltooi take onafhanklik
- ☐ C. Voorspel die neigings van toekomstige gebeure
- ☐ D. Dink voordat antwoorde op vrae verskaf word

8. 'n Onderwyser gee gereeld take aan sy of haar leerders in omstandighede wat soortgelyk is aan dit wat hulle later in hul tuisomgewing sal ervaar. Hierdie onderwyser se poging sal waarskynlik lei tot die bevordering van

- ☐ A. konsepleer
- ☐ B. ko-operatiewe leer
- ☐ C. ondersoekleer
- ☐ D. oordrag van leer

9. Watter van die onderstaande reekse kan 'n onderwyser toepas om foutiewe konsepte oor globale verhitting wat leerders huldig, te verander?

- ☐ A. Ondersoek → Oordrag → Hipotetiseer → Beoordeel
- ☐ B. Beoordeel → Hipotetiseer → Oordrag → Ondersoek
- ☐ C. Hipotetiseer → Ondersoek → Beoordeel → Oordrag
- ☐ D. Oordrag → Beoordeel → Ondersoek → Hipotetiseer

10. Sommige leerders in 'n klas het swak in vorige assesserings oor die oorsake en gevolge van klimaatsverandering gevaar. Watter van hierdie vorme van assessering voorsien die grootste geleenheid vir leerders tot groter begrip?

- ☐ A. Diagnostiese assessering
- ☐ B. Summatiewe assessering
- ☐ C. Grondlyn assessering
- ☐ D. Formatiewe assessering

==EINDE==

Dankie vir u deelname aan hierdie studie

Appendix 9: Collected Data - Respondents' Demographics

RESPONDENTS' DEMOGRAPHICS

ID	District	Sch. Location	Sch. Type	No. of Learners	No. of Teachers	No. of FET Geo. Teachers	Gender	Age	Qualification	Specialisation	No. of years in Teaching	Grade mostly taught	No. of Geo learners	Taught lessons on Climate Change last year?	Main source of info on climate science	Main source of info on climate pedagogy
1	Metro North	Rural	Mixed	<1000	<30	2	Female	<40	Masters	Geog and Education	>10	10	>50	Yes	Workshops/seminars	Peers and subject Advisor
2	Metro South	Urban	Mixed	<1000	<30	1	Female	>40	PG Diploma	Geography only	>10	12	>50	Yes	School textbooks	Internet
3	Metro North	Semi Urban	Mixed	<1000	<30	2	Male	<40	Bachelor	Others	<10	12	>50	Yes	School textbooks	School textbooks
4	Metro South	Urban	Mixed	>1000	>30	2	Male	>40	Honours	Geog and Education	>10	10	<50	Yes	Internet	School textbooks
5	Metro South	Urban	Mixed	>1000	>30	>2	Female	>40	Ordinary Dip	Geog and Education	>10	11	<50	Yes	Internet	Peers and subject Advisor
6	Metro South	Urban	Mixed	>1000	>30	>2	Male	<40	Bachelor	Geog and Education	>10	12	>50	Yes	Internet	Workshops and Seminars
7	Metro East	Urban	Mixed	>1000	>30	>2	Female	>40	PG Diploma	Geog and Education	>10	10	>50	No	NR	NR
8	Metro South	Urban	Mixed	>1000	>30	2	Female	>40	PG Diploma	Geography only	>10	10	>50	Yes	Newspaper	School textbooks
9	Metro North	Urban	Mixed	>1000	>30	>2	Male	>40	Honours	Others	>10	10	>50	Yes	Internet	School textbooks
10	Metro South	Urban	Mixed	>1000	>30	2	Female	>40	Ordinary Dip	Geog and Education	>10	12	>50	Yes	School textbooks	Workshops and Seminars
11	Metro South	Urban	Mixed	>1000	>30	>2	Female	>40	Honours	Geography only	>10	11	>50	No	NR	NR
12	Metro East	Semi Urban	Mixed	>1000	>30	2	Female	>40	Honours	Geog and Education	>10	11	>50	Yes	Radio	Workshops and Seminars
13	Metro South	Urban	Mixed	<1000	<30	>2	Male	>40	Honours	Geog and Education	>10	10	>50	Yes	School textbooks	School textbooks
14	Metro South	Urban	Girls only	>1000	>30	>2	Male	<40	Ordinary Dip	Geog and Education	>10	10	>50	Yes	Internet	Workshops and Seminars
15	Metro East	Urban	Mixed	>1000	>30	2	Male	>40	Honours	Geography only	>10	12	>50	Yes	Internet	School textbooks
16	Metro South	Urban	Mixed	>1000	>30	>2	Female	<40	Bachelor	Geography only	<10	11	>50	Yes	School textbooks	Workshops and Seminars
17	Metro South	Urban	Mixed	>1000	>30	>2	Female	<40	Bachelor	Geography only	<10	12	>50	Yes	School textbooks	School textbooks

18	Metro South	Urban	Mixed	<1000	<30	2	Male	>40	Ordinary Dip	Geography only	>10	10	>50	Yes	Internet	Internet
19	Metro South	Urban	Mixed	<1000	<30	>2	Female	<40	Ordinary Dip	Geog and Education	>10	12	>50	Yes	Internet	School textbooks
20	Metro South	Semi Urban	Mixed	>1000	>30	2	Female	>40	Bachelor	Geography only	>10	11	>50	Yes	School textbooks	School textbooks
21	Metro South	Urban	Mixed	<1000	<30	>2	Female	<40	Bachelor	Geog and Education	<10	10	>50	Yes	Internet	Workshops and Seminars
22	Metro South	Urban	Mixed	>1000	>30	>2	Female	>40	Bachelor	Geography only	>10	11	>50	Yes	Internet	School textbooks
23	Metro South	Urban	Mixed	>1000	<30	>2	Female	<40	PG Diploma	Geog and Education	<10	12	>50	Yes	School textbooks	Workshops and Seminars
24	Metro South	Urban	Mixed	>1000	>30	>2	Male	>40	Ordinary Dip	Others	>10	10	>50	Yes	School textbooks	School textbooks
25	Metro East	Urban	Mixed	<1000	<30	>2	Male	>40	Honours	Geog and Education	>10	10	>50	Yes	School textbooks	School textbooks
26	Metro East	Urban	Mixed	>1000	>30	2	Male	>40	PG Diploma	Geography only	>10	12	<50	Yes	School textbooks	School textbooks
27	Metro East	Semi Urban	Mixed	>1000	>30	>2	Female	>40	Honours	Geography only	>10	11	>50	No	NR	NR
28	Metro East	Semi Urban	Mixed	>1000	>30	2	Female	>40	PG Diploma	Geog and Education	>10	12	>50	Yes	School textbooks	School textbooks
29	Metro East	Urban	Mixed	>1000	>30	2	Female	<40	Ordinary Dip	Others	>10	10	>50	Yes	Internet	Internet
30	Metro East	Semi Urban	Mixed	>1000	>30	>2	Female	>40	Ordinary Dip	Geog and Education	>10	11	>50	Yes	Internet	School textbooks
31	Metro East	Urban	Mixed	>1000	>30	2	Male	>40	Ordinary Dip	Geography only	>10	12	>50	Yes	Internet	School textbooks
32	Metro East	Semi Urban	Mixed	>1000	>30	>2	Male	>40	Ordinary Dip	Geography only	<10	10	>50	Yes	School textbooks	Internet
33	Metro East	Rural	Mixed	>1000	>30	>2	Female	<40	Bachelor	Geography only	<10	12	<50	Yes	Internet	School textbooks
34	Metro East	Urban	Mixed	>1000	>30	>2	Male	>40	Bachelor	Geo and another subject	>10	10	>50	Yes	School textbooks	School textbooks
35	Metro East	Urban	Mixed	>1000	>30	2	Female	>40	PG Diploma	Geography only	>10	12	>50	Yes	School textbooks	Workshops and Seminars
36	Metro East	Semi Urban	Mixed	>1000	>30	>2	Male	<40	Bachelor	Geog and Education	<10	10	>50	Yes	Workshops/seminars	Peers and subject Advisor
37	Metro East	Urban	Mixed	>1000	>30	>2	Male	>40	Bachelor	Geog and Education	>10	12	>50	Yes	Internet	Workshops and Seminars
38	Metro East	Semi Urban	Mixed	>1000	>30	2	Female	>40	Bachelor	Geography only	>10	12	>50	Yes	Internet	Workshops and Seminars

39	Metro East	Semi Urban	Mixed	>1000	>30	>2	Female	<40	Bachelor	Geog and Education	<10	10	>50	Yes	School textbooks	Workshops and Seminars
40	Metro East	Urban	Mixed	>1000	>30	>2	Female	>40	Bachelor	Geog and Education	>10	12	<50	Yes	School textbooks	School textbooks
41	Metro East	Urban	Mixed	>1000	>30	2	Female	>40	Honours	Geog and Education	>10	10	>50	Yes	School textbooks	Peers and subject Advisor
42	Metro East	Urban	Mixed	>1000	>30	2	Male	>40	Bachelor	Geog and Education	>10	12	>50	No	NR	NR
43	Metro East	Urban	Mixed	>1000	>30	>2	Female	>40	Bachelor	Geography only	>10	12	>50	Yes	Internet	School textbooks
44	Metro East	Urban	Mixed	>1000	>30	2	Female	>40	Masters	Geography only	>10	12	>50	Yes	Internet	School textbooks
45	Metro East	Semi Urban	Mixed	>1000	>30	2	Male	>40	PG Diploma	Geography only	>10	12	>50	Yes	School textbooks	School textbooks
46	Metro East	Urban	Mixed	>1000	>30	>2	Male	>40	Ordinary Dip	Others	>10	11	>50	Yes	School textbooks	School textbooks
47	Metro East	Urban	Mixed	>1000	>30	>2	Male	>40	Bachelor	Others	>10	10	>50	Yes	School textbooks	Internet
48	Metro East	Semi Urban	Mixed	<1000	<30	2	Male	>40	PG Diploma	Geography only	>10	12	<50	Yes	School textbooks	School textbooks
49	Metro East	Semi Urban	Mixed	>1000	>30	2	Female	>40	PG Diploma	Geog and Education	>10	12	<50	Yes	Internet	Internet
50	Metro East	Urban	Mixed	>1000	>30	>2	Male	>40	Bachelor	Geog and Education	>10	12	>50	No	NR	NR
51	Metro East	Urban	Mixed	>1000	>30	>2	Female	>40	Ordinary Dip	Geog and Education	>10	10	>50	Yes	School textbooks	School textbooks
52	Metro East	Urban	Mixed	<1000	>30	1	Male	>40	Honours	Geography only	>10	10	>50	Yes	Internet	Workshops and Seminars
53	Metro East	Urban	Mixed	<1000	<30	1	Male	>40	Ordinary Dip	Geog and Education	<10	10	>50	Yes	Internet	Internet
54	Metro East	Urban	Mixed	>1000	>30	>2	Male	>40	PG Diploma	Geog and Education	>10	12	>50	Yes	School textbooks	Internet
55	Metro East	Urban	Mixed	>1000	>30	2	Male	>40	Honours	Others	>10	12	>50	Yes	School textbooks	School textbooks
56	Metro East	Semi Urban	Mixed	>1000	>30	2	Female	>40	Honours	Geography only	>10	10	>50	Yes	Newspaper	Workshops and Seminars
57	Metro East	Urban	Mixed	>1000	>30	>2	Female	>40	PG Diploma	Geog and Education	>10	11	>50	Yes	Internet	Internet
58	Metro East	Urban	Mixed	>1000	>30	1	Male	>40	Honours	Geog and Education	>10	10	>50	Yes	School textbooks	School textbooks
59	Metro East	Urban	Mixed	>1000	>30	>2	Male	>40	Honours	Geography only	>10	12	>50	Yes	Internet	School textbooks
60	Metro East	Urban	Mixed	>1000	>30	2	Female	>40	Honours	Geography only	<10	11	>50	Yes	School textbooks	Internet

61	Metro East	Urban	Mixed	<1000	<30	2	Female	>40	Bachelor	Geog and Education	>10	12	>50	Yes	School textbooks	Workshops and Seminars
62	Metro East	Urban	Mixed	<1000	<30	2	Male	<40	Bachelor	Geography only	<10	12	<50	Yes	Internet	School textbooks
63	Metro East	Urban	Mixed	<1000	>30	1	Female	<40	Honours	Others	<10	11	<50	Yes	Internet	School textbooks
64	Cape Winelands	Semi Urban	Mixed	>1000	>30	>2	Male	>40	PG Diploma	Geography only	>10	10	>50	Yes	School textbooks	Workshops and Seminars
65	Cape Winelands	Semi Urban	Mixed	>1000	>30	>2	Male	<40	Honours	Geog and Education	>10	11	>50	Yes	School textbooks	Workshops and Seminars
66	Cape Winelands	Semi Urban	Mixed	>1000	>30	>2	Male	>40	Honours	Geog and Education	>10	12	>50	Yes	Internet	School textbooks
67	Cape Winelands	Semi Urban	Mixed	>1000	>30	2	Female	>40	Bachelor	Geog and Education	>10	11	<50	No	NR	NR
68	Cape Winelands	Semi Urban	Mixed	>1000	>30	2	Male	>40	Ordinary Dip	Geog and Education	>10	10	>50	Yes	School textbooks	Workshops and Seminars
69	Cape Winelands	Semi Urban	Mixed	>1000	>30	2	Male	>40	Masters	Geog and Education	>10	12	>50	Yes	School textbooks	Workshops and Seminars
70	Metro South	Urban	Girls only	>1000	>30	2	Male	>40	PG Diploma	Geo and another subject	>10	11	>50	Yes	School textbooks	Peers and subject Advisor
71	Metro South	Urban	Girls only	<1000	<30	>2	Female	>40	Ordinary Dip	Others	>10	10	<50	Yes	Internet	Workshops and Seminars
72	Metro South	Urban	Mixed	>1000	>30	2	Male	>40	Honours	Geography only	>10	12	>50	Yes	School textbooks	School textbooks
73	Metro South	Urban	Mixed	<1000	<30	2	Male	>40	PG Diploma	Others	<10	10	>50	Yes	Internet	Workshops and Seminars
74	Metro South	Urban	Mixed	<1000	<30	>2	Female	>40	Bachelor	Geog and Education	<10	10	>50	Yes	School textbooks	Workshops and Seminars
75	Metro South	Urban	Mixed	>1000	>30	2	Female	>40	Bachelor	Geog and Education	>10	10	>50	Yes	School textbooks	Workshops and Seminars
76	West Coast	Rural	Mixed	>1000	>30	2	Male	>40	Bachelor	Geog and Education	>10	12	>50	Yes	Newspaper	Peers and subject Advisor
77	Metro South	Urban	Mixed	<1000	<30	>2	Male	>40	Ordinary Dip	Geography only	>10	10	<50	Yes	Internet	School textbooks
78	Metro South	Semi Urban	Mixed	<1000	<30	>2	Female	<40	Bachelor	Others	>10	10	>50	Yes	School textbooks	Internet
79	Metro South	Semi Urban	Mixed	>1000	>30	>2	Female	>40	Bachelor	Geog and Education	>10	11	>50	Yes	School textbooks	Workshops and

																Seminars
80	Metro South	Urban	Mixed	>1000	>30	>2	Female	>40	PG Diploma	Geography only	<10	12	>50	Yes	Newspaper	School textbooks
81	Metro South	Urban	Mixed	>1000	>30	>2	Male	<40	Bachelor	Geography only	<10	11	>50	Yes	Internet	Internet
82	Metro South	Urban	Mixed	<1000	<30	1	Male	>40	Bachelor	Geography only	<10	12	<50	Yes	School textbooks	School textbooks
83	Metro South	Urban	Mixed	<1000	<30	>2	Male	>40	Bachelor	Geography only	>10	12	>50	No	NR	NR
84	Metro South	Urban	Mixed	<1000	<30	2	Male	>40	Honours	Geography only	>10	12	<50	Yes	School textbooks	School textbooks
85	Metro South	Urban	Mixed	>1000	>30	>2	Male	>40	Masters	Others	<10	12	>50	Yes	Newspaper	Workshops and Seminars
86	Metro South	Semi Urban	Mixed	>1000	>30	>2	Female	<40	Bachelor	Geography only	<10	10	>50	Yes	School textbooks	School textbooks
87	Metro South	Urban	Girls only	<1000	>30	2	Female	>40	PG Diploma	Geography only	>10	12	<50	Yes	Workshops/seminars	Workshops and Seminars
88	Metro South	Urban	Mixed	>1000	>30	2	Female	>40	Bachelor	Geography only	>10	12	<50	Yes	Internet	Workshops and Seminars
89	Metro South	Urban	Mixed	>1000	>30	>2	Female	>40	PG Diploma	Geog and Education	>10	10	>50	Yes	Internet	School textbooks
90	Metro South	Urban	Mixed	>1000	>30	>2	Male	>40	Ordinary Dip	Others	>10	10	>50	Yes	Internet	School textbooks
91	Metro South	Urban	Mixed	<1000	<30	>2	Female	>40	Bachelor	Others	<10	10	<50	Yes	School textbooks	Workshops and Seminars
92	Metro East	Urban	Mixed	>1000	>30	>2	Female	>40	Honours	Geog and Education	<10	10	>50	Yes	School textbooks	School textbooks
93	Metro South	Urban	Mixed	>1000	>30	>2	Female	>40	Bachelor	Geog and Education	>10	11	>50	No	NR	NR
94	Metro South	Urban	Mixed	>1000	>30	>2	Male	<40	Bachelor	Geography only	<10	11	>50	Yes	Internet	School textbooks
95	West Coast	Rural	Mixed	>1000	>30	2	Male	>40	Bachelor	Geog and Education	>10	10	>50	Yes	School textbooks	School textbooks
96	Cape Winelands	Rural	Mixed	>1000	<30	2	Male	>40	Ordinary Dip	Geography only	>10	12	>50	Yes	Radio	Workshops and Seminars
97	West Coast	Rural	Mixed	<1000	>30	1	Female	<40	Bachelor	Others	<10	12	>50	Yes	Internet	Workshops and Seminars
98	West Coast	Semi Urban	Mixed	>1000	>30	2	Male	>40	Honours	Geog and Education	>10	12	>50	Yes	School textbooks	Internet
99	West Coast	Urban	Mixed	>1000	>30	2	Male	>40	Masters	Geog and Education	>10	12	>50	Yes	School textbooks	Workshops and Seminars

100	Eden and Karoo	Semi Urban	Mixed	>1000	>30	2	Male	>40	PG Diploma	Others	>10	12	>50	Yes	Internet	Peers and subject Advisor
101	Eden and Karoo	Urban	Mixed	>1000	>30	>2	Male	<40	Honours	Geog and Education	>10	12	>50	Yes	School textbooks	School textbooks
102	Eden and Karoo	Rural	Mixed	>1000	>30	>2	Male	>40	Ordinary Dip	Geography only	>10	10	<50	Yes	School textbooks	Peers and subject Advisor
103	Eden and Karoo	Urban	Mixed	<1000	>30	>2	Male	>40	PG Diploma	Others	>10	12	>50	Yes	School textbooks	School textbooks
104	Eden and Karoo	Semi Urban	Mixed	>1000	>30	2	Female	>40	PG Diploma	Geog and Education	>10	11	>50	Yes	School textbooks	School textbooks
105	Eden and Karoo	Rural	Mixed	<1000	<30	2	Male	>40	Masters	Geog and Education	>10	12	<50	Yes	Internet	Peers and subject Advisor
106	Eden and Karoo	Rural	Mixed	<1000	<30	1	Female	<40	Bachelor	Geog and Education	>10	10	<50	Yes	School textbooks	School textbooks
107	Eden and Karoo	Semi Urban	Mixed	>1000	>30	2	Male	>40	Bachelor	Geography only	>10	12	>50	Yes	School textbooks	Workshops and Seminars
108	Eden and Karoo	Urban	Mixed	<1000	>30	2	Female	>40	Ordinary Dip	Others	>10	12	<50	Yes	Internet	Workshops and Seminars
109	Eden and Karoo	Rural	Mixed	>1000	<30	2	Male	>40	Ordinary Dip	Geography only	>10	12	>50	Yes	Internet	Peers and subject Advisor
110	Eden and Karoo	Urban	Mixed	<1000	<30	2	Female	>40	Ordinary Dip	Geography only	>10	12	<50	Yes	School textbooks	School textbooks
111	Eden and Karoo	Urban	Mixed	<1000	>30	1	Female	>40	Ordinary Dip	Geog and Education	>10	10	>50	Yes	Internet	Peers and subject Advisor
112	Eden and Karoo	Rural	Mixed	>1000	>30	1	Male	>40	Bachelor	Geog and Education	>10	10	>50	Yes	Newspaper	School textbooks
113	Eden and Karoo	Urban	Mixed	>1000	>30	2	Male	>40	Ordinary Dip	Others	>10	12	>50	Yes	Internet	Workshops and Seminars
114	Eden and Karoo	Rural	Mixed	<1000	<30	1	Female	<40	Honours	Geography only	>10	10	>50	Yes	Internet	Workshops and Seminars
115	Eden and Karoo	Rural	Mixed	<1000	>30	2	Female	>40	Honours	Geog and Education	>10	12	>50	Yes	Internet	Peers and subject Advisor
116	Eden and Karoo	Rural	Mixed	<1000	<30	1	Male	>40	Honours	Others	>10	12	<50	Yes	School textbooks	Internet
117	Eden and Karoo	Semi Urban	Mixed	>1000	>30	2	Male	>40	Ordinary Dip	Geog and Education	>10	12	<50	Yes	Internet	Workshops and Seminars
118	Eden and Karoo	Urban	Mixed	<1000	<30	2	Male	>40	Bachelor	Geography only	>10	12	<50	Yes	School textbooks	Workshops and

																Seminars
119	Eden and Karoo	Rural	Mixed	<1000	>30	1	Female	<40	Bachelor	Geog and Education	<10	10	<50	Yes	Internet	Internet
120	Eden and Karoo	Urban	Mixed	>1000	>30	>2	Male	>40	Honours	Geography only	>10	12	>50	Yes	Newspaper	School textbooks
121	Eden and Karoo	Urban	Mixed	<1000	<30	1	Male	>40	PG Diploma	Geography only	>10	12	>50	Yes	Newspaper	School textbooks
122	Metro South	Urban	Boys only	<1000	>30	>2	Female	>40	Bachelor	Geography only	>10	12	>50	Yes	Internet	Peers and subject Advisor
123	Metro Central	Urban	Mixed	>1000	>30	2	Female	>40	PG Diploma	Geog and Education	<10	11	>50	Yes	School textbooks	Internet
124	Metro Central	Urban	Mixed	>1000	>30	2	Female	>40	Masters	Geog and Education	>10	12	>50	Yes	School textbooks	School textbooks
125	Metro Central	Urban	Mixed	>1000	>30	2	Female	>40	Honours	Geography only	>10	12	>50	Yes	School textbooks	School textbooks
126	Metro Central	Urban	Mixed	<1000	<30	2	Male	<40	Bachelor	Geography only	>10	12	>50	Yes	Internet	School textbooks
127	Metro Central	Urban	Mixed	<1000	>30	2	Female	>40	Bachelor	Geog and Education	>10	12	>50	Yes	Newspaper	School textbooks
128	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	Ordinary Dip	Geography only	>10	12	>50	Yes	Internet	Internet
129	Metro Central	Urban	Mixed	>1000	>30	2	Female	>40	Honours	Geography only	>10	12	>50	Yes	Television	School textbooks
130	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	Bachelor	Geography only	>10	11	>50	No	NR	NR
131	Metro Central	Urban	Mixed	>1000	<30	>2	Male	>40	Honours	Geography only	<10	12	>50	Yes	School textbooks	School textbooks
132	Metro Central	Urban	Mixed	<1000	<30	>2	Male	NR	NR	NR	NR	10	>50	Yes	School textbooks	Internet
133	Metro Central	Urban	Mixed	<1000	>30	1	Male	<40	Bachelor	Geog and Education	>10	12	<50	Yes	School textbooks	Internet
134	Metro Central	Urban	Mixed	<1000	<30	1	Female	>40	Honours	Geography only	>10	12	>50	Yes	School textbooks	Workshops and Seminars
135	Metro Central	Urban	Mixed	<1000	>30	>2	Male	>40	Honours	Geog and Education	>10	12	>50	Yes	Internet	School textbooks
136	Metro Central	Urban	Mixed	<1000	>30	>2	Female	>40	PG Diploma	Geo and another subject	>10	12	<50	Yes	Newspaper	Internet
137	Metro Central	Urban	Mixed	>1000	>30	2	Female	>40	Bachelor	Geo and another subject	>10	12	>50	Yes	School textbooks	Workshops and Seminars
138	Metro Central	Urban	Mixed	<1000	<30	2	Male	<40	PG Diploma	Geog and Education	>10	12	>50	Yes	Television	School textbooks
139	Metro Central	Semi Urban	Mixed	<1000	<30	2	Male	>40	Bachelor	Geog and Education	>10	12	>50	Yes	Newspaper	Internet

140	Metro Central	Urban	Mixed	<1000	<30	1	Male	>40	PG Diploma	Geog and Education	<10	12	>50	Yes	Newspaper	School textbooks
141	West Coast	Urban	Mixed	<1000	<30	1	Male	<40	Ordinary Dip	Geography only	>10	10	>50	Yes	Television	School textbooks
142	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	Bachelor	Geog and Education	>10	12	<50	Yes	Internet	Internet
143	Metro Central	Urban	Mixed	<1000	<30	2	Female	>40	Bachelor	Geog and Education	>10	12	>50	Yes	School textbooks	School textbooks
144	Metro Central	Urban	Girls only	<1000	<30	1	Female	<40	Bachelor	Geog and Education	<10	11	>50	Yes	School textbooks	Peers and subject Advisor
145	Metro Central	Urban	Girls only	<1000	>30	>2	Female	>40	Honours	Geography only	>10	12	>50	Yes	Internet	Peers and subject Advisor
146	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	Honours	Geography only	>10	10	>50	Yes	Internet	School textbooks
147	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	PG Diploma	Geog and Education	>10	12	>50	Yes	Internet	School textbooks
148	Metro Central	Urban	Boys only	<1000	>30	>2	Male	>40	Honours	Geog and Education	>10	12	>50	Yes	Internet	School textbooks
149	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	Honours	Geography only	>10	11	>50	Yes	School textbooks	Workshops and Seminars
150	Metro Central	Urban	Mixed	<1000	<30	2	Female	>40	PG Diploma	Geography only	>10	12	>50	Yes	Internet	School textbooks
151	Metro Central	Urban	Mixed	>1000	>30	>2	Male	>40	Honours	Geography only	>10	12	>50	Yes	Newspaper	School textbooks
152	Metro Central	Urban	Mixed	<1000	<30	1	Female	>40	Bachelor	Geography only	>10	12	<50	Yes	Internet	Internet
153	Metro Central	Urban	Mixed	<1000	<30	>2	Male	>40	Bachelor	Geography only	>10	12	>50	Yes	Newspaper	School textbooks
154	Metro Central	Urban	Mixed	>1000	>30	>2	Male	>40	Honours	Geography only	>10	12	>50	Yes	Newspaper	School textbooks
155	Metro Central	Urban	Mixed	<1000	<30	1	Male	>40	PG Diploma	Geography only	>10	12	<50	Yes	Internet	School textbooks
156	Metro Central	Urban	Mixed	<1000	<30	1	Female	>40	Honours	Geography only	>10	12	>50	Yes	Internet	School textbooks
157	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	Bachelor	Geog and Education	>10	12	<50	Yes	Television	Peers and subject Advisor
158	Metro Central	Urban	Mixed	<1000	<30	>2	Male	>40	Honours	Geography only	>10	12	>50	Yes	School textbooks	Internet
159	Metro East	Semi Urban	Mixed	<1000	<30	2	Male	>40	Bachelor	Geography only	<10	10	<50	Yes	Internet	Workshops and Seminars
160	Metro Central	Urban	Mixed	<1000	<30	1	Female	>40	Honours	Geography only	>10	12	>50	Yes	School textbooks	Internet
161	Metro Central	Urban	Mixed	<1000	<30	2	Female	>40	Honours	Geog and Education	>10	12	>50	Yes	Internet	School textbooks

162	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	Honours	Geography only	>10	12	>50	Yes	Internet	Internet
163	Metro Central	Urban	Mixed	<1000	<30	1	Female	>40	PG Diploma	Geog and Education	>10	12	>50	Yes	Internet	Workshops and Seminars
164	Cape Winelands	Semi Urban	Mixed	<1000	>30	2	Male	>40	Honours	Geog and Education	>10	12	<50	Yes	Newspaper	School textbooks
165	Cape Winelands	Semi Urban	Mixed	<1000	>30	2	Male	<40	Bachelor	Geog and Education	<10	10	<50	Yes	Internet	School textbooks
166	Overberg	Rural	Mixed	<1000	<30	2	Male	<40	Bachelor	Geog and Education	<10	12	>50	No	NR	NR
167	Overberg	Rural	Mixed	<1000	<30	2	Female	>40	Bachelor	Geography only	>10	12	>50	Yes	Peers and Subject Advisor	Peers and subject Advisor
168	Overberg	Rural	Mixed	<1000	<30	1	Female	>40	Bachelor	Geog and Education	<10	11	<50	Yes	Internet	School textbooks
169	Overberg	Rural	Mixed	<1000	<30	2	Male	<40	Ordinary Dip	Geog and Education	>10	10	<50	Yes	Internet	School textbooks
170	Overberg	Semi Urban	Mixed	<1000	<30	1	Male	>40	Honours	Geography only	>10	12	<50	Yes	Television	Workshops and Seminars
171	Overberg	Urban	Mixed	<1000	<30	1	Female	<40	Bachelor	Geography only	>10	11	<50	Yes	Internet	School textbooks
172	Overberg	Rural	Mixed	>1000	<30	1	Male	>40	PG Diploma	Geog and Education	>10	10	>50	Yes	Workshops/seminars	School textbooks
173	Overberg	Rural	Mixed	<1000	<30	2	Male	>40	Masters	Geography only	>10	12	<50	No	NR	NR
174	Metro North	Urban	Mixed	<1000	<30	1	Male	>40	PG Diploma	Geography only	>10	11	<50	Yes	School textbooks	School textbooks
175	Metro North	Urban	Mixed	>1000	>30	2	Female	>40	Ordinary Dip	Geog and Education	>10	12	>50	Yes	School textbooks	Internet
176	Metro North	Urban	Mixed	>1000	>30	2	Male	>40	Honours	Geography only	>10	12	>50	Yes	School textbooks	Workshops and Seminars
177	Metro North	Urban	Mixed	>1000	>30	>2	Male	>40	Bachelor	Geo and another subject	>10	12	>50	Yes	Internet	School textbooks
178	Metro North	Semi Urban	Mixed	>1000	>30	2	Male	>40	PG Diploma	Geog and Education	>10	12	>50	Yes	School textbooks	School textbooks
179	Metro North	Urban	Mixed	>1000	>30	>2	Female	<40	PG Diploma	Geog and Education	>10	11	>50	Yes	Internet	Television
180	Metro North	Urban	Mixed	>1000	>30	1	Female	>40	Bachelor	Geography only	>10	12	>50	Yes	School textbooks	School textbooks
181	Metro North	Urban	Mixed	<1000	<30	2	Female	>40	Honours	Geography only	>10	12	>50	Yes	Internet	School textbooks
182	Metro North	Urban	Mixed	<1000	<30	>2	Female	<40	Bachelor	Geog and Education	>10	12	<50	Yes	Internet	Workshops and Seminars

162	Metro Central	Urban	Mixed	<1000	<30	2	Male	>40	Honours	Geography only	>10	12	>50	Yes	Internet	Internet
163	Metro Central	Urban	Mixed	<1000	<30	1	Female	>40	PG Diploma	Geog and Education	>10	12	>50	Yes	Internet	Workshops and Seminars
164	Cape Winelands	Semi Urban	Mixed	<1000	>30	2	Male	>40	Honours	Geog and Education	>10	12	<50	Yes	Newspaper	School textbooks
165	Cape Winelands	Semi Urban	Mixed	<1000	>30	2	Male	<40	Bachelor	Geog and Education	<10	10	<50	Yes	Internet	School textbooks
166	Overberg	Rural	Mixed	<1000	<30	2	Male	<40	Bachelor	Geog and Education	<10	12	>50	No	NR	NR
167	Overberg	Rural	Mixed	<1000	<30	2	Female	>40	Bachelor	Geography only	>10	12	>50	Yes	Peers and Subject Advisor	Peers and subject Advisor
168	Overberg	Rural	Mixed	<1000	<30	1	Female	>40	Bachelor	Geog and Education	<10	11	<50	Yes	Internet	School textbooks
169	Overberg	Rural	Mixed	<1000	<30	2	Male	<40	Ordinary Dip	Geog and Education	>10	10	<50	Yes	Internet	School textbooks
170	Overberg	Semi Urban	Mixed	<1000	<30	1	Male	>40	Honours	Geography only	>10	12	<50	Yes	Television	Workshops and Seminars
171	Overberg	Urban	Mixed	<1000	<30	1	Female	<40	Bachelor	Geography only	>10	11	<50	Yes	Internet	School textbooks
172	Overberg	Rural	Mixed	>1000	<30	1	Male	>40	PG Diploma	Geog and Education	>10	10	>50	Yes	Workshops/seminars	School textbooks
173	Overberg	Rural	Mixed	<1000	<30	2	Male	>40	Masters	Geography only	>10	12	<50	No	NR	NR
174	Metro North	Urban	Mixed	<1000	<30	1	Male	>40	PG Diploma	Geography only	>10	11	<50	Yes	School textbooks	School textbooks
175	Metro North	Urban	Mixed	>1000	>30	2	Female	>40	Ordinary Dip	Geog and Education	>10	12	>50	Yes	School textbooks	Internet
176	Metro North	Urban	Mixed	>1000	>30	2	Male	>40	Honours	Geography only	>10	12	>50	Yes	School textbooks	Workshops and Seminars
177	Metro North	Urban	Mixed	>1000	>30	>2	Male	>40	Bachelor	Geo and another subject	>10	12	>50	Yes	Internet	School textbooks
178	Metro North	Semi Urban	Mixed	>1000	>30	2	Male	>40	PG Diploma	Geog and Education	>10	12	>50	Yes	School textbooks	School textbooks
179	Metro North	Urban	Mixed	>1000	>30	>2	Female	<40	PG Diploma	Geog and Education	>10	11	>50	Yes	Internet	Television
180	Metro North	Urban	Mixed	>1000	>30	1	Female	>40	Bachelor	Geography only	>10	12	>50	Yes	School textbooks	School textbooks
181	Metro North	Urban	Mixed	<1000	<30	2	Female	>40	Honours	Geography only	>10	12	>50	Yes	Internet	School textbooks
182	Metro North	Urban	Mixed	<1000	<30	>2	Female	<40	Bachelor	Geog and Education	>10	12	<50	Yes	Internet	Workshops and Seminars

Appendix 10: Respondents' Answers – CCSL items

RESPONDENTS' ANSWERS TO CLIMATE CHANGE SCIENCE ITEMS

ID	CCS-Q1 - Factual - C - 1	CCS-Q2 - Factual - D - 1	CCS-Q3 - Conceptual - D - 2	CCS-Q4 - Conceptual - B - 2	CCS-Q5 - Conceptual - B - 2	CCS-Q6 - Conceptual - A - 2	CCS-Q7 - Procedural - C - 3	CCS-Q8 - Conceptual - B - 2	CCS-Q9 - Conceptual - C - 2	CCS-Q10 - Conceptual - B - 2	CCS-Q11 - Factual - B - 1	CCS-Q12 - Procedural - B - 3	CCS-Q13 - Procedural - A - 3	CCS-Q14 - Procedural - C - 3	CCS-Q15 - Procedural - B - 3
1	B	D	D	B	D	B	C	A	C	D	C	A	D	C	B
2	B	D	D	B	B	A	C	B	D	B	A	B	A	A	C
3	B	D	B	B	B	A	C	B	D	C	D	A	A	D	C
4	B	D	D	B	B	A	C	B	A	B	C	A	A	C	C
5	B	D	D	B	A	A	C	B	D	C	A	B	A	C	B
6	B	D	C	B	C	A	B	B	D	B	A	B	A	C	B
7	B	D	NR	B	NR	A	NR	B	D	B	NR	A	C	C	A
8	B	D	D	B	A	A	C	B	D	C	C	A	A	C	NR
9	C	D	D	B	B	A	C	B	B	B	A	A	A	C	A
10	B	D	D	B	B	A	C	B	B	C	D	D	A	C	B
11	B	D	B	B	B	A	A	B	B	C	A	A	A	C	B
12	D	C	D	B	A	D	B	C	B	D	C	B	A	C	C
13	B	D	D	B	NR	A	C	B	A	D	C	A	A	D	B
14	A	D	A	B	C	A	C	A	D	C	D	B	B	B	NR
15	B	C	D	B	D	A	C	B	D	B	A	B	A	D	A
16	B	D	D	B	B	A	C	B	B	C	B	B	A	B	NR
17	B	D	D	B	NR	A	C	C	B	C	NR	NR	NR	D	B
18	B	D	D	B	D	A	C	B	D	B	D	B	A	D	B
19	B	D	D	B	D	D	C	C	D	C	C	D	D	D	NR
20	NR	D	D	B	D	A	C	B	D	B	D	C	A	A	B

21	B	D	D	C	NR	C	D	B	D	A	C	A	D	C	C
22	B	D	D	B	D	A	A	C	D	C	C	A	A	C	NR
23	B	D	NR	B	B	A	NR	B	C	B	C	A	A	C	B
24	B	D	D	B	A	A	D	B	D	B	D	A	A	C	B
25	B	A	D	B	B	A	B	B	B	B	C	B	A	C	B
26	B	D	D	B	D	C	C	B	D	C	B	B	A	D	B
27	A	D	D	B	B	A	A	B	D	A	A	C	C	D	B
28	B	D	D	B	B	A	C	D	D	D	C	B	D	A	C
29	A	D	A	B	NR	A	C	B	D	C	C	A	A	A	B
30	A	C	D	D	NR	B	A	B	D	A	NR	B	A	C	A
31	C	D	D	B	B	A	A	B	B	C	D	A	A	C	B
32	B	D	D	A	NR	B	C	C	D	B	C	B	B	C	C
33	B	D	D	B	C	B	B	C	D	B	C	B	A	C	B
34	B	D	D	D	B	A	C	B	D	B	D	A	A	A	B
35	B	D	D	B	C	A	C	B	B	B	A	A	A	D	B
36	B	D	D	B	NR	C	C	B	D	NR	A	A	A	C	B
37	B	D	D	B	NR	A	C	B	A	B	B	B	A	C	B
38	NR	NR	D	C	NR	B	A	NR	D	C	NR	A	C	C	B
39	B	D	D	B	C	A	C	C	D	B	NR	D	C	C	B
40	B	D	D	B	B	A	NR	C	D	NR	B	C	C	A	D
41	B	D	D	B	B	A	C	C	D	NR	B	A	A	C	B
42	B	A	D	C	B	A	D	B	D	B	A	B	A	D	B
43	A	D	D	B	C	A	C	B	D	D	B	A	A	D	B
44	A	D	D	B	B	A	D	B	D	B	B	B	A	A	B
45	A	D	D	B	B	A	A	C	D	B	B	A	A	C	D
46	A	D	D	B	D	A	C	B	D	C	A	D	A	C	C
47	B	D	D	C	C	A	C	B	B	D	C	A	A	C	C
48	B	D	D	B	A	A	A	B	D	B	NR	D	A	C	B
49	B	D	D	B	D	A	C	B	A	B	A	A	A	NR	B
50	B	D	D	B	A	A	D	B	D	C	D	A	A	A	A

51	C	D	D	B	D	D	C	NR	B	D	D	A	A	C	D
52	B	D	D	B	B	A	C	B	D	B	B	A	A	C	B
53	B	C	D	A	B	A	D	B	D	B	B	B	A	C	NR
54	B	D	D	B	B	A	C	B	D	A	B	A	A	C	NR
55	C	D	D	B	A	A	C	B	NR	B	A	A	A	A	B
56	A	D	D	B	B	A	C	C	D	NR	NR	NR	NR	NR	NR
57	B	D	D	B	B	A	C	B	C	B	B	NR	A	C	NR
58	C	D	D	B	A	A	D	B	C	B	A	A	A	C	A
59	B	D	D	B	B	A	C	B	A	B	B	B	A	C	B
60	B	D	D	B	C	A	D	C	A	B	B	A	A	D	B
61	D	D	D	B	D	A	A	B	D	C	C	D	A	C	B
62	B	D	D	B	B	A	D	B	D	B	C	A	A	C	B
63	D	D	D	C	B	A	C	B	D	B	C	B	A	C	C
64	B	D	D	B	NR	A	A	B	D	D	NR	C	A	C	NR
65	B	D	D	B	B	A	A	D	A	NR	A	A	A	B	B
66	B	D	D	C	B	A	A	B	A	D	A	A	C	D	A
67	NR	D	D	B	NR	A	C	C	NR	C	NR	A	A	C	B
68	C	D	D	B	B	A	C	C	C	B	A	B	A	A	C
69	B	D	D	B	C	D	D	B	D	A	A	B	A	C	A
70	B	D	D	B	D	A	C	B	A	B	B	B	A	A	C
71	C	D	D	B	D	A	D	B	B	B	A	B	A	C	A
72	B	D	D	B	B	A	D	B	D	B	B	B	A	C	B
73	B	D	D	B	C	A	C	B	D	C	NR	B	A	A	A
74	B	A	D	A	NR	A	NR	NR	NR	B	A	NR	C	C	B
75	D	D	B	B	NR	A	B	NR	NR	NR	D	NR	NR	NR	NR
76	B	D	D	B	B	A	C	B	B	B	A	B	A	A	B
77	B	D	D	B	B	A	A	B	D	B	A	B	A	D	C
78	B	C	B	B	C	B	B	B	C	B	B	NR	B	A	B
79	A	D	D	A	A	B	A	A	D	D	D	A	A	A	C
80	B	D	NR	NR	NR	B	NR	C	NR	B	NR	NR	A	C	B

81	B	D	D	C	B	A	D	C	D	D	B	C	D	D	A
82	B	D	D	B	D	A	D	B	B	C	D	D	A	A	B
83	B	D	D	B	D	A	D	C	D	C	B	C	A	C	B
84		D	D	B	B	B	D	B	D	C	B	C	A	C	B
85	B	D	D	B	C	A	A	B	D	B	A	B	A	A	B
86	B	D	D	A	B	A	D	C	D	B	B	A	B	A	B
87	B	D	D	B	D	A	D	B	D	B	B	B	A	C	B
88	B	D	D	B	D	A	C	B	D	C	C	B	A	C	D
89	C	D	D	B	B	A	C	B	D	C	D	A	D	C	A
90	B	C	D	C	B	A	C	B	A	B	B	C	A	C	C
91	A	D	C	B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
92	B	D	D	B	D	A	D	B	D	B	D	A	A	D	B
93	B	D	D	B	D	A	D	B	D	B	D	A	A	D	B
94	A	A	D	C	C	A	C	A	D	B	C	B	A	D	B
95	B	D	D	B	C	A	C	B	A	A	A	B	A	C	B
96	D	D	D	B	B	A	C	B	C	B	A	A	A	A	B
97	B	D	D	B	D	D	C	B	B	B	B	A	A	C	A
98	B	D	D	B	NR	A	A	B	D	B	NR	B	NR	NR	B
99	B	D	D	B	B	A	C	B	B	B	C	A	A	A	B
100	B	D	D	B	C	A	D	B	B	B	C	B	C	C	B
101	B	D	D	B	B	A	C	B	D	B	A	A	A	C	B
102	A	D	D	B	B	A	C	D	D	B	B	A	A	C	B
103	B	C	D	B	C	A	C	B	D	B	B	C	A	C	B
104	B	C	D	B	A	A	C	B	D	B	A	A	A	C	B
105	B	D	D	B	B	A	D	B	D	B	B	B	A	C	B
106	B	D	D	B	B	A	C	D	D	B	D	D	C	A	B
107	B	D	D	C	C	A	C	B	D	B	B	C	A	A	B
108	B	C	D	B	A	D	B	NR	A	D	NR	C	A	C	B
109	B	D	D	B	D	A	C	B	D	B	B	B	A	C	B
110	B	D	D	NR	A	A	A	B	A	A	C	A	D	C	A

111	B	D	D	B	D	A	C	B	D	B	B	B	A	C	B
112	B	D	D	B	NR	A	C	B	D	B	B	A	A	C	B
113	B	D	D	B	B	A	C	C	C	D	D	D	A	C	B
114		D	D	B	D	A	A	C	A	C	A	A	A	A	B
115	A	D	D	B	B	A	C	B	NR	NR	C	B	B	NR	B
116	A	D	D	B	D	A	A	C	D	B	B	A	A	A	B
117	B	D	D	B	D	A	D	B	C	B	B	C	C	D	B
118	B	D	D	B	B	A	C	B	B	B	D	B	A	D	A
119	B	D	D	B	C	A	C	C	A	B	A	A	A	B	A
120	B	D	D	B	B	A	C	C	D	D	B	A	A	C	C
121	B	D	D	B	B	A	C	C	D	D	B	A	A	C	B
122	B	D	D	B	C	D	D	B	B	B	B	B	A	C	B
123	B	D	D	A	NR	A	D	NR	A	D	NR	NR	NR	NR	B
124	B	D	D	B	B	A	NR	B	D	C	NR	B	A	C	NR
125	B	D	C	B	A	A	C	B	D	B	A	B	A	C	B
126	A	D	B	B	A	A	A	B	A	B	A	D	A	C	B
127	B	D	D	B	D	A	C	B	D	C	A	B	A	D	A
128	C	D	D	B	D	A	C	B	D	B	B	B	A	A	B
129	B	C	D	B	A	A	C	B	A	B	NR	A	A	A	B
130	B	D	A	B	A	A	C	B	D	D	B	B	A	C	B
131	B	C	D	B	B	A	NR	B	NR	B	A	NR	A	C	B
132	A	C	D	B	B	A	D	B	A	C	B	B	A	C	D
133	D	D	C	B	B	A	C	B	A	C	C	A	A	C	B
134	B	D	D	B	D	D	C	B	D	B	C	B	A	C	B
135	C	D	NR	B	B	A	C	B	D	D	B	C	A	C	A
136	B	D	D	B	B	A	C	B	D	B	B	A	A	C	A
137	B	D	D	A	B	A	D	B	D	B	D	C	A	D	B
138	B	D	D	B	C	A	C	B	D	B	B	D	A	A	B
139	B	A	D	B	D	A	C	C	NR	A	NR	A	A	B	B
140	B	D	NR	B	A	A	NR	B	D	B	NR	A	A	D	NR

141	B	D	C	B	D	B	B	C	D	B	D	C	A	A	C
142	A	D	D	B	B	A	C	B	D	D	A	D	A	A	B
143	B	D	D	B	A	A	C	B	B	B	C	B	A	D	D
144	A	D	D	C	C	A	B	B	D	D	D	A	A	C	B
145	B	D	D	B	B	A	C	B	D	B	B	B	A	A	A
146	B	D	D	B	A	A	C	B	D	C	A	B	A	C	B
147	B	D	C	A	B	A	C	B	A	C	B	B	A	C	C
148	B	D	D	A	D	A	C	B	D	B	B	A	A	A	B
149	B	D	D	B	B	A	C	B	D	B	A	B	A	A	B
150	B	D	D	B	D	A	C	C	A	C	C	A	C	A	B
151	B	D	D	B	B	A	A	B	B	B	D	A	A	C	B
152	B	D	C	B	D	A	C	B	B	B	B	B	A	C	B
153	C	D	D	B	B	A	C	B	A	B	A	B	A	C	B
154	B	D	A	B	B	A	C	B	D	B	B	A	A	C	B
155	B	C	B	B	A	A	A	B	D	B	B	D	B	D	D
156	B	D	D	B	D	A	C	B	C	C	A	B	A	C	B
157	B	C	D	B	C	A	A	A	B	B	C	D	D	D	D
158	B	D	C	B	B	A	A	B	C	B	B	B	D	C	B
159	A	D	D	B	D	A	A	B	A	C	D	A	A	A	A
160	D	D	D	B	B	A	C	B	D	B	D	A	A	A	A
161	B	D	D	B	D	A	C	C	D	B	D	C	C	C	C
162	B	C	D	B	A	A	D	B	D	B	A	A	A	C	B
163	B	D	A	B	D	A	D	B	D	B	NR	C	A	C	NR
164	B	D	D	C	B	A	D	B	D	B	B	A	A	C	C
165	B	D	D	B	B	B	D	B	D	B	B	C	A	C	C
166	B	D	D	B	NR	A	C	B	D	B	B	NR	B	C	NR
167	B	D	D	C	A	A	D	B	C	B	D	A	A	C	B
168	B	C	D	B	B	A	C	B	D	B	D	A	A	C	A
169	B	D	D	B	B	A	A	C	B	B	D	B	D	C	A
170	B	D	D	B	D	A	C	B	D	B	B	D	A	C	B

171	B	D	D	B	B	B	C	B	D	D	B	A	A	C	C
172	B	D	D	B	B	A	C	B	NR	B	B	B	A	A	B
173	B	D	D	B	B	A	C	B	NR	NR	B	A	A	C	B
174	NR	D	D	C	NR	B	A	C	D	C	B	C	A	C	NR
175	B	D	D	B	B	C	C	B	A	NR	D	B	A	C	A
176	B	D	D	B	A	A	C	B	D	B	B	B	A	C	B
177	B	D	C	B	B	A	C	B	D	B	B	A	A	A	B
178	B	C	A	B	B	A	C	B	B	B	A	A	A	C	B
179	C	D	A	B	B	A	C	B	B	B	D	A	A	B	B
180	C	D	B	B	B	A	C	B	A	B	B	A	A	C	B
181	B	D	D	B	B	A	C	C	D	B	D	A	A	C	B
182	B	D	D	B	A	D	C	B	D	B	A	B	A	C	A
183	B	D	D	B	A	D	C	B	D	B	A	B	A	C	A
184	B	C	D	B	B	A	C	B	D	B	C	D	A	A	D
185	B	D	D	B	B	A	C	A	C	D	C	A	C	D	B
186	B	D	D	B	D	A	D	B	C	C	D	A	A	C	B
187	B	D	D	B	A	A	NR	B	A	B	A	A	A	A	NR
188	B	D	D	B	B	A	C	B	D	B	D	C	A	D	B
189	B	D	D	B	B	A	C	B	D	B	C	A	A	C	B
190	B	D	D	C	D	A	C	B	D	B	B	B	A	C	NR
191	B	D	D	B	B	A	C	B	D	B	A	A	C	C	B
192	B	D	D	B	NR		NR	B	A	D	NR	NR	NR	A	B
193	B	D	D	B	B	A	A	B	C	B	A	B	C	C	B
194	B	D	D	B	B	A	D	B	A	C	A	B	A	C	B

Appendix 11: Respondents' Answers - CCPL items

RESPONDENTS' ANSWERS TO CCP ITEMS

ID	CCP-Q1 - Conceptual - B – 2	CCP-Q2 - Factual - D – 1	CCP-Q3 - Conceptual - A – 2	CCP-Q4 - Factual - C – 1	CCP-Q5 - Conceptual - D – 2	CCP-Q6 - Conceptual - D – 2	CCP-Q7 - Procedural - C – 3	CCP-Q8 - Procedural - D – 3	CCP-Q9 - Procedural - C – 3	CCP-Q10 - Procedural - D – 3
1	B	D	A	D	D	A	A	D	A	C
2	A	D	A	A	D	D	C	A	A	B
3	C	D	A	B	D	D	D	A	D	A
4	C	D	C	C	D	D	A	C	C	C
5	B	D	A	C	D	D	D	B	A	D
6	A	C	A	A	A	D	D	C	C	B
7	A	D	A	A	A	A	A	C	C	A
8	A	C	A	C	D	D	B	D	C	D
9	B	D	A	A	A	D	B	D	A	A
10	C	D	A	B	A	D	D	C	C	C
11	A	D	C	C	C	D	B	B	A	A
12	C	D	A	A	C	D	A	A	B	A
13	C	D	A	A	D	D	C	A	C	C
14	C	B	A	A	A	NR	D	D	D	C
15	C	D	A	C	C	D	B	D	B	A
16	C	B	B	B	B	D	A	D	A	A
17	C	B	B	B	NR	NR	C	NR	A	A
18	B	D	A	D	D	D	D	A	A	C
19	C	D	NR	A	D	D	C	B	A	B

20	C	B	A	C	D	D	A	B	C	D
21	C	B	B	C	D	D	D	A	B	B
22	B	B	A	A	A	D	B	D	A	C
23	A	B	A	B	A	D	A	B	C	A
24	A	D	A	C	C	D	B	B	A	A
25	A	D	A	D	B	D	C	C	A	C
26	C	D	A	D	D	D	D	B	C	C
27	B	D	A	C	A	D	C	B	C	A
28	A	D	C	D	A	D	A	C	D	B
29	A	D	A	A	D	B	A	A	A	C
30	B	A	B	D	A	B	D	B	A	D
31	D	D	A	D	A	D	B	C	A	A
32	C	D	A	B	C	D	B	B	C	B
33	A	A	B	A	D	D	A	B	C	C
34	A	D	B	D	D	D	D	D	C	C
35	A	D	A	A	A	D	D	C	C	A
36	C	D	A	A	B	D	NR	C	A	A
37	A	D	A	A	A	D	B	A	C	C
38	NR	NR	B	D	D	D	D	A	NR	B
39	A	D	A	D	NR	B	B	NR	D	D
40	B	A	C	D	B	D	B	D	B	C
41	A	D	A	D	D	D	D	C	C	C
42	C	D	D	C	D	B	D	B	C	A
43	B	D	A	A	A	A	A	D	C	B
44	A	D	A	A	A	D	A	B	C	A
45	B	B	A	A	A	D	D	B	C	A
46	B	B	D	B	C	D	C	B	B	A
47	B	D	A	D	D	B	C	C	D	D
48	A	D	A	A	A	D	D	C	C	A
49	A	A	A	C	C	D	C	C	C	D

50	C	D	A	A	A	B	D	B	C	D
51	B	D	B	D	D	D	D	A	A	B
52	B	D	A	A	D	D	D	B	A	C
53	C	B	A	A	D	D	C	A	A	B
54	NR	D	A	NR	A	NR	B	A	A	B
55	A	B	A	NR	D	D	A	B	C	A
56	NR	D	A	NR	A	D	B	NR	C	A
57	C	D	C	D	B	D	D	B	A	A
58	A	B	A	A	B	D	D	C	B	A
59	B	B	A	B	C	D	A	B	C	B
60	A	C	C	A	B	C	C	C	C	A
61	B	D	A	C	B	C	D	C	C	C
62	C	D	C	C	D	D	D	D	D	D
63	B	B	A	C	D	D	C	C	C	A
64	B	D	C	B	C	B	C	B	A	C
65	B	D	C	D	A	C	A	D	NR	NR
66	A	D	A	A	D	A	B	D	C	C
67	NR	B	A	C	D	D	D	C	A	A
68	A	D	B	C	A	D	A	C	A	C
69	A	B	A	C	A	D	C	C	C	A
70	A	C	A	D	A	D	B	C	C	A
71	A	D	A	A	A	D	B	D	A	A
72	B	D	A	D	B	D	A	C	C	A
73	A	D	A	C	A	B	D	C	C	D
74	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
75	B	C	C	D	B	D	B	B	B	B
76	B	B	B	D	D	D	D	B	A	B
77	B	D	B	C	C	D	C	D	C	D
78	NR	NR	NR	NR	NR	C	C	B	C	C
79	B	C	B	D	D	NR	NR	NR	NR	NR

80	A	D	A	NR	NR	NR	NR	C	B	C
81	B	C	C	B	C	B	D	C	B	D
82	B	D	NR	D	D	C	A	B	A	A
83	A	B	C	C	C	C	C	D	C	C
84	C	D	A	A	C	D	B	D	C	D
85	C	B	A	A	C	B	A	D	A	A
86	A	D	B	A	A	D	B	B	A	C
87	A	D	A	C	A	D	D	D	A	C
88	C	B	A	C	D	D	D	D	C	C
89	B	B	A	A	C	D	A	D	C	A
90	A	A	A	A	B	D	C	C	C	B
91	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
92	C	D	A	A	A	D	C	A	A	C
93	C	D	D	A	A	NR	C	A	C	C
94	A	D	C	C	A	D	A	C	B	C
95	B	C	B	C	A	D	B	C	D	C
96	A	B	A	C	D	D	C	C	D	C
97	B	D	A	A	A	D	A	A	C	B
98	A	D	NR	B	B	D	NR	B	A	A
99	B	D	A	A	A	A	A	A	C	A
100	C	A	A	A	D	C	C	C	C	D
101	B	C	C	D	B	B	D	A	A	D
102	A	C	C	C	A	B	B	C	C	C
103	A	D	A	D	D	D	A	C	A	C
104	B	D	D	A	C	A	B	C	A	A
105	A	B	A	C	B	D	D	D	C	D
106	B	D	B	B	D	A	D	C	A	D
107	B	D	A	A	A	D	D	B	C	B
108	A	D	A	C	C	B	A	A	C	B
109	C	D	D	C	A	D	D	D	C	D

110	A	D	D	A	C	B	A	B	B	D
111	C	D	A	A	A	D	NR	A	B	D
112	A	B	A	C	A	D	B	C	C	A
113	B	B	D	D	B	C	D	NR	C	A
114	C	B	A	A	C	D	C	C	C	D
115	B	C	A	A	A	D	C	C	C	D
116	A	D	A	C	C	B	D	B	C	C
117	B	D	D	A	C	A	B	C	A	A
118	A	D	B	C	A	D	C	A	C	D
119	C	D	A	D	C	D	C	B	B	D
120	A	D	A	C	A	D	A	C	C	D
121	A	D	A	C	A	C	B	C	C	D
122	C	D	A	C	C	D	C	D	B	A
123	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
124	D	B	A	D	C	B	B	D	C	A
125	A	D	A	D	A	D	D	D	A	D
126	B	D	A	A	B	D	B	C	A	C
127	A	B	A	D	B	D	C	B	C	A
128	A	B	A	A	C	D	C	A	C	A
129	A	D	A	C	D	A	A	A	B	C
130	A	D	A	A	C	D	D	D	C	A
131	B	B	NR	C	C	D	A	D	D	A
132	C	C	C	D	B	A	D	B	A	C
133	A	D	A	C	A	D	C	B	C	B
134	B	D	A	C	D	D	B	A	C	A
135	A	D	A	A	D	D	D	D	C	A
136	A	D	A	C	D	D	D	C	A	C
137	B	D	A	A	D	A	B	A	C	D
138	A	D	B	C	C	B	C	D	C	A
139	B	D	C	C	B	C	B	A	B	B

140	C	D	A	A	A	D	D	B	A	A
141	C	D	A	D	D	D	C	C	A	A
142	C	C	A	C	A	D	D	D	B	A
143	C	D	B	C	C	D	B	A	D	D
144	A	D	A	C	A	B	B	C	C	A
145	C	D	A	A	A	D	D	D	C	D
146	A	D	A	A	A	B	B	D	A	C
147	A	D	A	A	C	C	D	C	A	A
148	A	D	A	C	A	D	B	C	A	A
149	A	D	A	D	A	D	D	D	A	D
150	C	C	A	D	C	D	D	C	C	A
151	A	D	A	D	A	D	C	A	C	C
152	A	D	D	C	B	B	C	C	C	C
153	B	C	A	D	D	B	A	C	A	C
154	A	B	A	C	B	D	D	C	B	A
155	B	D	A	D	C	D	D	D	D	A
156	B	D	NR	C	C	D	C	B	C	C
157	C	A	D	A	C	B	D	A	B	B
158	B	B	D	D	C	B	C	C	C	A
159	C	B	C	A	D	B	C	C	A	D
160	A	D	B	A	D	A	D	A	C	C
161	C	B	A	D	D	D	C	D	A	C
162	A	D	B	C	C	D	A	C	B	A
163	A	D	A	A	D	B	D	D	A	D
164	A	D	B	C	C	D	C	B	A	D
165	C	D	B	C	A	D	C	A	C	D
166	B	B	A	C	D	D	C	C	C	B
167	A	NR	NR	NR	NR	NR	C	C	C	NR
168	C	A	C	A	C	NR	B	A	C	D
169	C	D	A	D	B	D	C	D	A	C

170	C	A	A	A	A	D	C	B	C	A
171	B	B	A	C	B	D	A	A	A	D
172	A	C	A	C	B	D	C	B	A	A
173	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
174	C	NR	C	A	C	NR	A	A	C	C
175	B	A	A	C	A	D	A	C	C	B
176	B	D	A	C	A	D	B	B	C	A
177	B	A	A	A	D	A	A	B	C	C
178	B	A	A	C	NR	A	A	A	C	D
179	A	A	A	D	B	A	A	C	A	C
180	A	D	A	A	A	D	B	C	C	C
181	A	D	A	C	A	D	D	B	A	C
182	B	B	A	C	D	D	D	D	A	A
183	B	D	A	C	D	D	D	D	A	A
184	C	D	C	D	C	D	C	C	C	C
185	C	D	D	D	A	B	B	B	A	B
186	B	D	D	A	B	D	D	C	C	D
187	A	D	A	A	D	D	A	D	A	C
188	A	D	A	C	A	B	D	D	C	C
189	B	D	A	B	D	D	D	D	B	D
190	A	D	A	C	A	D	C	B	A	A
191	A	C	A	A	D	D	B	A	C	A
192	C	D	NR	C	D	NR	A	A	NR	A
193	A	D	A	C	A	B	A	C	D	D
194	C	A	A	D	A	B	NR	C	C	D